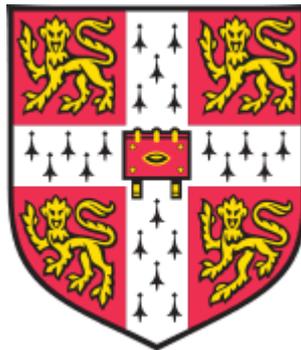


Hydrocarbon spills in continental waters: a new regulatory approach in light of Mexico's energy reform



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Abstract

The research assesses if Mexico will benefit from the enactment of an environmental quality standard (EQS) for water contaminated with hydrocarbons, in light of Mexico's energy reform. In addition, the research assesses the institutional challenges faced when trying to enforce such EQS, and the design elements for any such standard. The research compares the current regulatory framework for water contaminated with hydrocarbons in Mexico, which requires the preparation of an environmental risk assessment (ERA) for each case, with the enactment of two hypothetical EQS. The comparison is conducted using a multi-criteria analysis and information is gathered via expert interviews. Results indicate that Mexico will benefit from the enactment of an EQS, however several institutional challenges need to be solved to ensure effective enforcement.

Acronyms

ASEA	Hydrocarbon Environmental Health and Safety Agency <i>Agencia de Seguridad, Energía y Ambiente</i>
CONAGUA	National Water Commission <i>Comisión Nacional del Agua</i>
EPA	United States Environmental Protection Agency
ERA	Environmental Risk Assessment <i>Estudio de Riesgo Ambiental</i>
EQS	Environmental Quality Standard
LAN	National Water Law <i>Ley de Aguas Nacionales</i>
LFRA	Environmental Accountability Law <i>Ley Federal de Responsabilidad Ambiental</i>
LGPGIR	Federal Waste Law <i>Ley General de Prevención y Gestión de Residuos</i>
M&A	Merger and Acquisition
NGO	Non-Government Organization
NOM	Official Mexican Standard <i>Norma Oficial Mexicana</i>
O&G	Oil and Gas
PEMEX	National Oil Company <i>Petróleos Mexicanos</i>
PROFEPA	Federal Environmental Procurator <i>Procuraduría Federal de Protección al Ambiente</i>
RLGPGIR	Regulation of the Federal Waste Law <i>Reglamento de la Ley General de Prevención y Gestión de Residuos</i>
SEMARNAT	Secretariat of Environment and Natural Resources <i>Secretaría de Medio Ambiente y Recursos Naturales</i>
USA	United States of America

1. Introduction

In 2013 Mexico enacted its energy reform, which among other modifications, switched the oil and gas (O&G) market from a government operated monopoly (PEMEX), to an open market in high, mid and downstream O&G. The Mexican Government has received permit applications from 113 different companies to operate in the O&G market [31], and committed investment in O&G due to the reform was worth \$175 thousand million US dollars in February 2018, and is expected to keep growing [28]. Mexico is starting a whole new era in O&G.

Mexico's environmental regulatory framework identifies the remediation actions to be conducted when hydrocarbon contamination is present in natural soil; such actions are identified under the soil Environmental Quality Standard (EQS) NOM-138-SEMARNAT/SSA1-2012. Also, as required by several international environmental conventions to which Mexico is signatory, the country maintains a national contingency plan for hydrocarbons and toxic substance spills in marine waters.

However, when hydrocarbon contamination occurs in continental waters, either groundwater or surface water, there are no clear environmental regulations, no EQS to remediate, nor contingency plans to follow. The waste law regulation (RLGPGIR) identifies that any contamination from which no EQS is enacted requires the preparation of an environmental risk assessment (ERA) to identify the target clean-up concentrations; and the preparation of a remediation plan which will propose a remediation technique and a sampling protocol. Therefore, every continental water contamination case uses a different 'solution recipe', which usually takes years to be implemented and is not always based on science.

The energy reform also created the new Hydrocarbon Industry Environmental and Health and Safety Agency (ASEA), whose mission includes providing legal certainty to the hydrocarbon sector. To generate such regulatory certainty, ASEA enacted 14 regulatory instruments in 2016 and 10 in 2017 [39]. None of these related to water EQS for hydrocarbon contamination.

By comparing the current regulatory requirements with the hypothetical scenario of the enactment of an EQS for hydrocarbon contamination in continental waters, the research assesses, using expert interviews, which scenario most benefits Mexico (sections 3, 4.1 and 4.2). The research also assesses the criteria to be considered when designing such EQS (section 4.3), and the institutional challenges to face when trying to enforce such EQS (section 4.4). Furthermore, the research briefly explores

different public policy approaches to regulation of water quality (section 4.5), and future research topics (section 5). Finally, conclusions are drawn (section 6).

2. Motivation

Hydrocarbon spills associated to transport of fuel by road, pipeline operations, or hydrocarbon stealing activities from pipelines are one the main soil and water pollution causes in Mexico [29]. Before the energy reform PEMEX conducted all such activities, but nowadays the market is shifting towards global O&G players, which desire legal certainty for their activities.

Between 2014 and 2017 the number of environmental emergencies associated with chemicals spills increased twofold. The main cause was hydrocarbon spills [19-22, 65]. Although available statistics do not differentiate between soil and groundwater contamination, aggregate numbers show the significant impact. Table 1 provides the Federal Environmental Procurator (PROFEPA) environmental incidents¹ annual statistics.

Table 1 Mexico's environmental incidents

Year	Total Incidents	Spill incidents (% of total)
2017	2,176	1,782 (82)
2016	1,961	1,822 (93)
2015	1,562	1,331 (85)
2014	1,020	825 (74)

According to the Secretariat of Environment and Natural Resources (SEMARNAT) [29] the most spilled chemicals in Mexico are gasoline and diesel, which generate high toxic impacts, compared to other heavy oil products where smouldering is the main concern [18].

Table 2 provides selected ASEA statistics for reported hydrocarbon spills impacts occurred from March 2015² to December 2017 [65].

¹ In 2017 PROFEPA and ASEA started to publish independent statistics, before that only PROFEPA registered environmental incidents. The 2017 PROFEPA annual report accounts 652 environmental incidents, from which 258 were spills. ASEA reports that 1524 spills occurred during 2017. It is unclear if the ASEA data includes the PROFEPA data, but based on current tendencies, it is assumed both numbers are independent. The table shows the sum of PROFEPA and ASEA numbers.

² ASEA was founded in March 2015.

Table 2 Hydrocarbon spills

State	2015		2016		2017		Accumulated affected area [m2]
	Spills	Impacted area [m2]	Spills	Impacted area [m2]	Spills	Impacted area [m2]	
Tlaxcala	11	26,038	47	109,751	16	4,580	140,369
Guanajuato	321	57,546	837	64,685	1,048	17,521	139,752
Tabasco	14	112,668	24	21,892	7	945	135,505
Mexico	10	21,593	23	47,907	24	10,707	80,207
<i>Nation wide</i>	<i>505</i>	<i>306,424</i>	<i>1,297</i>	<i>326,445</i>	<i>1,524</i>	<i>67,799</i>	<i>700,668</i>

There are no clear statistics that show how many of the spills are associated to hydrocarbon theft. However, in 2017 PEMEX identified a historical maximum of 10,363 illegal pipeline connections for hydrocarbon theft [36], and media coverage shows spills from illegal activities on a daily basis.

In addition to the high frequency of spills and its widespread coverage, water remediation time currently takes years. A timely response for water contamination is of the utmost importance due to the migratory nature of contamination in surface and groundwater. Soil contamination often occurs within a single property, but water contamination spreads easily and could affect agriculture, fishing and tourism, among other activities.

3. Methodology

The research assesses three regulatory scenarios, and compares them using a multi-criteria analysis [30].

3.1 Scenarios

A. Status Quo

The status quo requires the water polluter to conduct emergency actions, to minimize environmental impacts, to prepare and submit for approval an Environmental Risk Assessment (ERA) following the SEMARNAT published guidelines [22],³ and to prepare and submit a remediation plan for approval. The ERA needs to propose environmental quality remediation (clean-up) standards, and the remediation plan needs to propose remediation techniques and sampling protocols. If the polluter belongs to the hydrocarbon industry,⁴ the ERA is submitted to ASEA; if not, the ERA is submitted to SEMARNAT. In both instances, the ERA is further submitted to the National Water Commission (CONAGUA) for approval. If contamination is present in surface water, the CONAGUA Department of Surface Water is the approval authority; if contamination is in groundwater, then the CONAGUA Groundwater Department is the approval authority. If contamination is present in surface and groundwater, both departments need to work together to approve the remediation plan. Within all this process, PROFEPA is the only authority that has jurisdiction to supervise the remediation actions.

B. Chemical Families

The scenario proposes the enactment of a water EQS for hydrocarbon contamination⁵ based on chemical families. Specifically, the scenario proposes to mimic the hydrocarbon chemical families used in the soil EQS NOM-138-SEMARNAT/SSA1-2012: total petroleum hydrocarbon (TPH) light, medium and heavy fractions [26]. Scenario B would regulate the main contaminants spilled by volume in Mexico [29].

C. Chemicals of Concern

The scenario proposes the enactment of a water EQS for hydrocarbon contamination considering some of the most toxic, miscible, and commonly used chemicals in fuels [32-35,

³ The ERA may not follow the published guidelines, but at least it needs to comply with an EPA level 3 ecological risk assessment [17, 24].

⁴ As defined by the Hydrocarbon Law.

⁵ The document uses indistinctively EQS and remediation standard.

58]. Specifically, the scenario proposes quality criteria for Benzene, Toluene, Ethyl Benzene and Xylene (BTEX), and Polycyclic Aromatic Hydrocarbons (PAH). The PAHs in question are the ones included into the NOM-138-SEMARNAT/SSA1-2012: benzo[a]pyrene; dibenz[a,h]anthracene; benzo[a]anthracene; benzo[b]fluoranthene; benzo[k]fluoranthene; and indeno[1,2,3-cd]pyrene.

Scenarios B and C require absence of light non-aqueous phase liquid (LNAPL) product (free product or free phase). As the research focuses in the hydrocarbon industry, and not the chemical industry (thus excluding halogenated hydrocarbons), the research does not consider dense non-aqueous phase liquid (DNAPL) products [37].

Mexico has two types of regulatory standards, Mexican Official Standards or NOM, and Mexican Standards or NMX. A NOM is a mandatory standard and a NMX is a reference standard, which becomes mandatory if a NOM requests its use. The research proposes the enactment of a NOM, and the meaning of standard within the research needs to be understood as synonym of NOM.

3.2 Criteria

The criteria used to compare the scenarios was selected following the guidelines established by the literature for multi-criteria assessment [30], considering the criteria for adequate public policy [80], considering the criteria for adequate contamination regulations [75], and relying on the professional experience of the applicant.⁶ Seven criteria are used to compare the scenarios:

1. Remediation Cost
2. Remediation Time
3. Human Health
4. Ecosystem Health
5. Legal Certainty
6. Industry Benefits
7. Environmental Authority Benefits

Industry and Environmental Authority benefits consider other indirect benefits in addition to remediation cost and time, and legal certainty.

⁶ +10 years of experience in contamination and regulatory compliance matters.

3.3 Data collection

Data collection was conducted using expert interviews. Each interviewee was requested to sign a participation approval of consent form, which included a project description and data management, record keeping and confidentiality disclaimers. A total of eighteen telephone and in person interviews⁷ were conducted. Both qualitative and quantitative data were collected [1-18]. From the eighteen interviews, sixteen were structured interviews and two were unstructured.

Structured interviews were conducted to answer two questionnaires: a general questionnaire equal for all participants, and a specialized questionnaire based on the interviewee’s field of experience. The general questionnaire elicited information about regulatory knowledge, criteria assessment and weight, opinion about environmental authority resources, and standard design elements. The specialized questionnaires elicited information associated to environmental litigation, regulatory loopholes, remediation costs, corporate policies, environmental insurance, authority regulatory approaches, among other information, as appropriate to each field of expertise. Table 3 provides basic statistics about the structured interviews.

Table 3 Research Participants

Field of expertise	Conducted Interviews	Relevant data
Environmental lawyers	3	Tier 1&2 law firms
Environmental authorities	2	ASEA and SEMARNAT
Environmental consultancy firms	3	Tier 1 firms. Two with certified remediation services included
Environmental remediation companies	2	Certified remediation companies
Environmental insurance	3	Main player in the market included
Manufacturing industry	3	Interviewees supervise 68 manufacturing facilities with ~45,000 employees

Unstructured interviews were conducted with an oil spill emergency response expert to inquire about the time-sensitivity of oil spills in watercourses [18]; and with the director of the fund in charge of claims from maritime oil spills, to inquire about transferability of experiences to non-marine water spills [11].

The top 5 gasoline retail distributors in the country were invited to the research, but none agreed to participate. The Health Secretariat refused to participate as reportedly they do not have jurisdiction over the matter. CONAGUA personnel were invited to participate; informal communications about

⁷ One interview consisted in a team of 3 persons.

the need of higher approvals was received, however no approval of consent was received. PEMEX, the Administrative Chamber for Environmental matters from the Supreme Court, the Mexican Hydrocarbon company's association (AMEXHI), the environmental biogeochemical laboratory from the National University (UNAM), researchers from the state of Morelos University (UAEM) and Monterrey Tec (ITESM) did not respond to the submitted invitations.⁸

Seventeen interviews were conducted in Spanish and one in English.⁹ Information provided by the interviewees is cited where appropriate. However, certain sensitive, confidential, or direct criticisms of the authorities are cited anonymously as [0]. Relevant Spanish references are provided in *italics*.

3.4 Literature Review

The 2010 National Remediation Program [29] identifies that Mexico does not have an integral regulatory framework and that EQS for water contamination are required. In the 2011 National Standard Program¹⁰ (PNN), SEMARNAT requested for the first time the legal analysis for the enactment of a water EQS. The requested EQS was solely associated to aquifers contaminated with hydrocarbons. The 2011 PNN indicates that such EQS would be enacted by December 2011 [40]. The 2014 and 2015 PNNs revisit the need for the enactment of such standard, referencing a publication date by December of each year [41, 42]. The 2015 PNN supplement indicates that SEMARNAT and CONAGUA cancelled the analysis for the enactment of the EQS, as such responsibility now relies on ASEA [44]. In the 2016-2018 PNNs, neither SEMARNAT, CONAGUA nor ASEA mention any EQS. Up to 2018 the legal analysis for the enactment of such EQS has not been initiated.

Research associated to remediation techniques for water contamination, the assessment of contamination in several Mexican hydrological basins, and its ecological impacts, is widely available [85-88]. However, as far as the author is aware, no academic research has been published regarding remediation standards for hydrocarbon or other chemical contamination for Mexico's water. International procedures on how to obtain such EQS, and the benefits from having clean water are available in international literature [82-84].

On March 22, 2018, the Proposal for the Enactment of the Environmental Remediation and Restoration of the Heavily Polluted Hydrological Basins [63] was submitted to the Lower Chamber

⁸ Some invitations were conducted by email, some by phone. Communications and invitations were repeatedly conducted.

⁹ When cited, any potential mistranslation is solely the author's responsibility.

¹⁰ The PNN (*Programa Nacional de Normalización*) is the program that identifies the need for the enactment of new regulations, and the modification or abrogation of existing regulations.

(*Cámara de Diputados*). According to the online legislative system, the proposal is under consideration for the Environmental and the Budgeting Committees [64]. However, the ordinary period for the Lower Chamber closed on April 30, 2018, and the issue was not addressed. As such, the current legislative team would not be able to further assess the matter.¹¹ The purpose of the law appears to force the government to remediate polluted hydrological basins, not to establish the EQS needed to conduct the remediation. According to the proposal, independent EQS will be required for each hydrological basin identified as heavily polluted.

¹¹ Mexico will have Legislative Chamber elections on July 2, 2018.

4. Results

The results section is structured in a way that allows the reader to easily refer to a specific issue, topic or assessment; and aims to help the reader navigate the document. The easy access to previous or further sections is essential in the document, as the reader is referenced in several instances to other sections for further guidance or information.¹²

4.1 Scenarios

Experts were requested to rank each of the three scenarios using the seven comparison criteria. A rank of 1 represents the best option (cheaper, faster, healthier, etc.), while a rank of 3 represents the worse scenario (expensive, lengthy, etc.). Experts could rank two, or the three scenarios in the same level. If two scenarios were ranked as 1, then the remaining scenario was ranked as 3; however, if a tie existed as second-best option, both scenarios were ranked as 2. Table 4 shows the scenario rankings.¹³

Table 4 Scenarios ranking

Scenario	Average	Frequency		
		1	2	3
A. Status Quo	2.8	7	5	86
B. Chemical Families	1.5	49	45	4
C. Chemicals of Concern	1.4	63	30	5

Experts had a clear tendency to prefer scenarios B and C over A. Nevertheless, the following positive opinions associated to scenario A are worth considering:

- Ramirez [3] indicates that “in an ideal world, where environmental authorities operate properly and industry adequately assess the environmental risk, scenario A will be the best one... however as the authority will never respond on time and industry will always seek to minimize costs... a scenario as A, even though the potentially most efficient, faster, and flexible, will only generate more disruption [to the remediation]”.
- Ellis [4] indicates that “time is money, and in a specific case, scenario A could be cheaper, but as authorities do not respond, you do not know how much it [the remediation] will cost you”.

¹² One of the main conclusions of the research (section 6) is that water contamination criteria and factors are endogenous; reason why it is necessary to have easy access and reference to such elements.

¹³ Only structured interviews considered for calculations. Two interviews are not considered within scenario ranking; in one the expert identified his/her chemical knowledge would not allow him/her to properly respond, while one expert did not answer the question.

- Hicks [15] identifies that “... the status quo [scenario A] is more specific, provides more details. However, as it is the one that takes more time to conduct any action, the ecosystem ends-up being heavily impacted. As methodology it is more effective, but in reference to time response, scenario B and C are faster”.

A concern during the research design was potential ‘anchoring’ for scenario B, due to participant familiarity with the soil remediation standard. However, based on the results obtained, no anchoring effect appears to have biased the experts. Grant [9] did identify, however, that scenario B, if enacted, could be accepted faster than C, as Industry would already be familiar with its structure.

4.2 Criteria

Experts were requested to value the seven criteria used to compare each scenario, assuming that those are the only relevant criteria for the enactment of a water EQS for hydrocarbon contamination, and that there is a total amount of 100 points to be split among the criteria. Table 5 summarizes the results.¹⁴

Table 5 Criteria valuation

Criteria	Maximum	Minimum	Average	Std. deviation
1. Remediation Cost	30	5	14.6	5.8
2. Remediation Time	30	5	14.6	6.5
3. Human Health	50	8	22.6	11.8
4. Ecosystem Health	30	8	19.5	6.8
5. Legal Certainty	25	3	12.6	5.5
6. Industry Benefits	20	1	9.7	5.6
7. Environmental Authority Benefits	15	0	6.4	3.8

Due to the word and time limitations for the dissertation, the initial research design assumed that the criteria of Human Health and Ecosystem Health will improve due to the existence of an EQS; therefore, no further research was conducted for those two criteria. As such, experts were requested to weigh again the criteria, but without considering the previously mentioned ones. Table 6 summarizes the selected results.

¹⁴ One interview is not considered within the criteria evaluation as one expert joint several criteria into cost. One interview consisted of three experts, and all provided a criteria valuation.

Table 6 Selected criteria valuation

Criteria	Maximum	Minimum	Average	Std. deviation
1. Remediation Cost	40	10	24.0	7.5
2. Remediation Time	40	15	24.3	6.6
5. Legal Certainty	50	10	21.9	10.1
6. Industry Benefits	35	8	17.5	6.5
7. Environmental Authority Benefits	20	5	12.3	4.5

Results indicate that the most important criteria to be considered when drafting the standard are Human Health and Ecosystem Health, followed by Remediation Cost, Remediation Time and Legal Certainty, and in a third level are Industry Benefits and Environmental Authority Benefits. The experts criteria ranking is consistent with international criteria ranks used for water EQS [75].

Experts agree that all the relevant criteria are considered in the research. However, according to the interviews, in addition to the stakeholders assessed, the following actors may also be relevant:

- Exposed communities. Bustamante [1] indicates that two social actors are not included into the assessment: the local communities adjacent to the mature oil fields auctioned as part of the energy reform, and the communities where hydrocarbon theft from pipelines are common. Aguirre [12] also mentions contamination displacement communities. Between 40-70% of Mexico's oil production is generated from mature fields [25], and PEMEX maintains a network of approximate 17,000 kilometres of oil pipelines [45], with hydrocarbon theft in 25 states [36]. Due to the number of potential communities affected, and its widespread location along the whole country, this assessment does not consider such stakeholders. Research shows that there is no record of communities displaced by hydrocarbon contamination in Mexico [95].

4.2.1 Remediation Cost

"Industry tries not to follow the soil remediation standard to the letter, as it implicates very high costs; remediation companies are expensive, the no-further action certificate is also expensive to obtain... Industry try to find a parallel mechanism to solve the contamination, either litigation that ceases the remediation responsibility, or voluntary remediation" [14].¹⁵

The cost structure of remediation will vary greatly depending on the technique to be used. However, using a general approach, the structure can be composed of:

- Professional service costs including consultants, remediation company services and lawyers;

¹⁵ Remediation without an authority approved ERA and remediation plan.

- Lost production cost, if applicable;
- Drilling cost for environmental sampling at the initial and final characterization;
- Remediation per se, including raw materials and equipment for the selected technique;
- Laboratory cost: initial, monitoring and confirmatory sampling; and
- Hazardous waste disposal costs.

According to environmental remediation experts, scenarios B and C could reduce the cost of a water remediation project in the following ranges:

- Between 20-30% of cost associated to remediation companies' professional services could be saved. Greater savings could be achieved considering that lawyers may not be needed if a standard is enacted [4].
- The administrative cost for remediation companies' professional services ranges between 15-20% of the overall remediation project cost. This portion of that cost could be reduced 50% if a standard is enacted [7].
- The enactment of a standard could reduce the overall remediation cost of non-complex projects between 10-15% [15].
- The enactment of a standard could reduce the overall remediation cost by 30% [16].

Although the ranges of cost reductions provided are not homogeneous, and are provided using different cost frameworks, in all cases experts agree that cost savings would be significant. Experts agree that most of the cost reduction would be generated from time saved in respect of dealings with environmental authorities, when compared with scenario A (section 4.2.2).

4.2.2 Remediation Time

"If a standard is enacted, the time for a remediation could be reduced at least by 50%. At present, the time spent by authorities in approving the remediation plans exceed the time spent in conducting those remediation in reality"[7].

The sequence of events for a water remediation in the current regulatory approach is shown in figure 1.

Figure 1 Remediation incident sequence



Pursuant to article 144 from the waste law regulation (RLGPGIR), SEMARNAT is required to approve the remediation plans within 60 working days. According to the experts, the common approval time is in fact several years. For example, the longest time one expert has been dealing with an approval for a remediation plan is 9 years and counting. However, the ‘know who’ (specially in CONAGUA) and the ‘who you are’ (small vs large multinational player) plays a role in determining such delay.

The research identified five main factors for the long administrative approval time for the remediation processes:

1) Lack of human resources by the authority

“The knowledgeable personnel spread when ASEA was created, however ASEA is not really enforcing the matter”[9]. The issue is further discussed in section 4.4-9.

2) Inadequate technical capabilities of the authority

“Even the authorities [mainly CONAGUA] are struggling to understand the engineering and science behind risk-based remediation practices, and this results in delays of regulatory decisions and unclear criteria being used” [7]. The issue is further discussed in section 4.4-8

3) Government official accountability (*responsabilidad de servidor público*).

“The government official accountability is a serious matter, as such, they [government officials] try to over document the matter [remediation]... they are taking care of his/her job, not the environment” [6].

Government officials can be liable for issuing environmental permits, such a remediation approval program, if such permits do not comply with relevant legal requirements. With missing criteria, there is an incentive to delay approval, and request as much information as possible before taking any action.

4) CONAGUA willingness to attend the matter

“We have found a great deal of reluctance from CONAGUA in opening administrative procedures, even when the matter has already been dealt with. We provide the technical proposal, approved by SEMARNAT, who is our ally in the matter, and it is us who are pushing the authorities to document what we are doing, so our clients have the opportunity to document what actions have been conducted” [0]. “It is the local authorities [fire marshal and civil protection] who are pushing for remediation to be conducted, there is no more federalized central power” [0].

Ruiz [17] identifies that CONAGUA has repeatedly rejected its responsibilities in contamination matters, and is reluctant to cooperate with SEMARNAT in providing technical opinions. Ruiz [17] also identifies that the last two federal administrations (2007-2012 and 2013-2018) were not willing to deal with water matters as a priority, based on the number of standards enacted or updated by CONAGUA. According to the Economy Secretariat [66], from 2007 to 2017 SEMARNAT enacted or updated 31 standards and CONAGUA only 3.¹⁶ For comparison, the Mexico City municipal administration enacted 3 water related standards [78] in the same period, and from 2015 to 2017 ASEA enacted 8 standards for the hydrocarbon industry.

5) Negotiation process

Several experts agree that regulatory uncertainty (refer also to section 4.2.3) generates conditions in which the approval of the ERA and remediation plan becomes a negotiation with the authority, which takes significant time, and deviates from the main goal of environmental protection. A better understanding of the impacts of having a negotiation power dynamic are shown in the experts' words:

- “You enter into negotiations with authorities that do not want, and are not prepared to take decisions... no one wants to decide, no one wants to do anything... we have suggested to seat all four parties [polluter, remediation company, SEMARNAT and CONAGUA] to expedite the issues, however the authorities always reject the offer” [4].
- “The remediation plan appears to be more a convincing effort from the consultant towards the authority, than a legal clarity; and convincing people takes time” [5].
- “As the matter is not regulated, the issue becomes a negotiation bargain, and the result depends on the government official taking the case... CONAGUA will always want more,

¹⁶ SEMARNAT has wider administrative responsibilities than CONAGUA, however, a factor of 10X appears disproportionate.

so you prepare your second-best proposal and submit it to them, so when CONAGUA comes back to you, you can submit your best proposal” [6].

When analysing the factors, it is clear they are endogenous, a vicious cycle that further delays the approval processes, and that requires that all factors are dealt with at the same time; no step-wise approach can solve the time issues.

4.2.3 Legal Certainty

“The legal system will benefit [in scenario B or C], as the obligation to remediate could be objectively measured” [1].

All experts agree that scenarios B and/or C provide more legal certainty than A. Some of the reasons for that are that the Environmental Accountability Law (LFRA) “allows open and ambiguous parameters of how to repair the environmental damage” [1], and “although scenario A could use approved methodologies and reach acceptable conclusions, these may be subject to the experience of the government official approving the remediation plan” [15].

“A legal system that provides legal certainty guides those subject to the law. It permits those subject to the law to plan their lives with less uncertainty. It protects those subject to the law from arbitrary use of state power.” [51]. The following paragraphs will discuss each of these three legal certainty elements, in addition to water contamination litigation.

1) Guideline

“Everybody is eager to have a remediation standard that tells you if you are doing right or not” [1].

The objectives from the emergency standard that originally regulated soil quality for hydrocarbon contamination, NOM-EM-138-ECOL-2002 [47], in addition to setting the soil quality criteria, were to establish the soil characterization and restoration process; in other words, to guide the remediation process. The same happens for the official standards that follow, NOM-138-SEMARNAT/SS-2003 [27] and NOM-138-SEMARNAT/SSA1-2012 [26]. Due to the heterogeneity of remediation techniques and potential quality criteria in water remediation processes, a guideline, just as in soil contamination, would greatly reduce legal uncertainty.

2) Uncertainty

“Investors find it funny, or peculiar, that there are no elements to quantify its risk [due to uncertainty]” [1].

It is not possible to accurately appraise the value of legal certainty in national or foreign direct investment, as the indifference curves and utility functions for the players cannot easily be determined [53], and a two-person cooperative game does not adequately reflect the challenges towards public goods consumption. However, it is well documented that investment is reduced with uncertainty [54, 55, 74, 76].

One of the main objectives of the energy reform is to generate investment in the O&G sector, while one of the main objectives of ASEA is to provide legal certainty to the sector [56]. As such, the enactment of the standard will allow several different, but supportive goals, from an assortment of actors, to be achieved.

3) Arbitrary power

“Due to the quality of the government that Mexico has, we don’t have a regulator that has the tools to navigate uncertainty, and that opens the door for discretion, which becomes arbitrariness” [1].

The Regulatory Impact Assessment (*Manifestación de Impacto Regulatorio* -MIR) for the NOM-138-SEMARNAT/SS-2002 identifies as a regulatory objective the prevention of discretion for authorities when granting no-further-action status for remediation [52]. The lack of water EQS, and the administrative procedure where several environmental authorities ‘collaborate’ into the approval process for water remediation, generates several opportunities for discretion and arbitrary situations.

Several experts agree [4, 7, 10, 16] that there is no technical consistency on remediation plan approvals, and that SEMARNAT and CONAGUA play ‘hot potato’ among themselves about who approves what.

Ruiz [17] indicates that the soil contamination regulatory framework was carefully designed to limit high environmental authorities’ decisions. Specifically, the regulation was drafted in

such a way that remediation approvals plans need to be based on technical issues and the 'boss' has little manoeuvre to change such remedial programs. However, the regulatory framework for water contamination is blurry, and as such high officials in CONAGUA take discretionary decisions.

4) Litigation

The environmental lawyers interviewed identify that none has participated in a litigation associated with soil or water contaminated with hydrocarbons. They also indicate that litigation in the matter is not the most advisable strategy, unless "the authority remediation plan is so expensive, that is worth fighting it" [6].

However, Orellana [14] identifies that although ASEA has an internal policy to conduct corrective enforcement to try to avoid punitive litigation; there are hundreds or perhaps thousands of cases, the majority managed internally by PEMEX's legal counsel. PEMEX litigates 100% of contamination cases: initially they challenge the legality of the process, and if they lose the case, then they challenge the chain of custody for the samples. In non-PEMEX contamination cases, litigation is present in approximately 30% of instances, and ASEA wins approximately 90% of the cases.¹⁷ Having EQS will reduce legality challenges and will provide ASEA and/or CONAGUA with better litigation tools.

4.2.4 Industry Benefits

Experts agree that the greatest benefits Industry obtains from the enactment of a standard are the three previous discussed topics: savings in remediation, a shorter time for solving the problem, and legal certainty. However, experts identified three additional 'indirect' benefits that Industry would obtain.

1) Environmental insurance

Regarding environmental insurance, "80% of the cost is based on your exposure and how you handle contingencies, while 20% is based on [insurance] demand. However, with a higher demand, the cost structure could be 60-40%" [2]. As such, with a higher demand for insurance, generated either by a push (regulation) or pull (Industry voluntary behaviour) strategy, Industry would benefit from cheaper insurance coverage, *ceteris paribus*. Nevertheless, it is important to note that "the insurer is who should decide the coverage to be obtained, and

¹⁷ ASEA only deals with soil contamination.

not be the authorities who decide what coverage needs to be secured, because if decided by the authorities, only the minimum coverage will be obtained” [2].

If scenario C is enacted, and the insurance industry links coverage to the chemicals listed under such scenario, “Industry will be really comfortable as the risk is parametrized and recognized in a holistic way, and therefore risk will be transferred toward the insurance coverage” [14].

2) Specialized contractors supply

The lack of environmental regulation associated with water contamination incentivizes Industry to not remediate [2, 4, 5, 6, 7, 8, 12, 17]. Industry is only “complying with wastewater discharge parameters, but that does not ensure no contamination is generated” [7]. “As there is no accountability, we [Industry] are delaying it [remediation], and there is nothing that stop us from continuing to operate business as usual” [0].

The status quo generates almost no water remediation in practice, which reduces the provision of specialized services. When Industry does try to remediate, one of its main challenges is to find adequate service providers [3, 10, 17]. As such, the enactment of a standard would generate a remediation market that will incentivize the offer of specialized services. In addition to the savings discussed in section 4.2.1, the market competition between specialized suppliers will drive costs further down, a double benefit for Industry.

3) Mergers and Acquisitions (M&A)

“M&A was the key element that detonated environmental issues to be deal at decision making levels, before that we only dealt with the environment in an operational level” [3]. “There are two main reasons why large corporations conduct remediation processes; M&A and internal standards” [16].

Mexican regulations require a SEMARNAT approval for transactions of contaminated properties (LGPGIR article 71 and RLPGIR article 127). “SEMARNAT approval is required to determine remedial actions for the buyer, seller or both, and does not prevent the execution of commerce and civil law” [61].

Industry, environmental consulting, and remediation companies, acknowledge that the authorities are not contacted in several ‘minor’ hydrocarbon contamination projects. The

main reasons for not contacting the authorities is the administrative burdensome imposed by the authority, the lengthy time required to solve the issue, and the costs generated from these factors. In a M&A, time is usually the most relevant factor for Industry; accordingly, several M&A transactions from contaminated properties are deal privately (section 4.2.2). “If the client decides not to contact the authorities, we document everything as if they were going to be contacted... if for some reason the authorities do notice the issue, the penalty is just an administrative fine” [0].

“In the transaction process the most complicated part was to convince the buyer that the site was remediated... but we never involved the authorities” [0]. One of the legal strategies for being in legal compliance during the transaction is to conduct the Phase I Environmental Site Assessment (assessment of potential contamination) before the transaction; establish a financial trust for the (potential) future remediation before the transaction; and to conduct the Phase II Environmental Site Assessment (soil sampling and confirmation of contamination) once the transaction has already been conducted. However, when the remediation process from a privately managed transaction does not go as planned, Industry goes to arbitration, and to be seen as a company dealing with environmental issues in arbitration is not good for public image in the financial markets [3].

The enactment of a standard will not only benefit Industry in providing legal certainty within the remediation process (section 4.2.3), but will also provide a smoother M&A processes for contaminated sites.

4.2.5 Environmental Authority Benefits

In addition to having a standard that allows better handling of environmental matters, it does not appear that environmental authorities have significant ‘indirect’ benefits. Sosa [2] indicates that having a standard would make it easier to impose fines, but that should not be the aim of an environmental standard. Ruiz [17] even indicates that having a standard generates more problems than benefits, as it will require CONAGUA to generate administrative procedures, hire people, request budget, among other activities not currently being conducted.

Several experts mention corruption as a potential benefit for the authority in case the standard allows for discretion, however none further explored their thoughts. It appears the corruption comments were more a social conversation based on Mexico’s corruption standing [69] than a formal thought.

The challenges that environmental authorities face in the matter are discussed in section 4.4.

4.3 Standard Design

There is widespread literature, both from academia and from the Mexican government, about the elements, goals, mechanisms, or characteristics that a law, regulation or standard needs to consider [79-81].

The summary of the elements/ characteristics/ factors that experts believe would produce an adequate water EQS based on the current Mexico's political, cultural and institutional situation, and the sections where such elements are discussed, is presented below:

- Remediation should not be that onerous (4.2.1, 4.2.4-2 and 4.5.2-4).
- Remediation should be expedite (4.2.2).
- The authority should not a protagonist (4.2.3-3)
- Authorities should have a solid institutional framework with adequate human resources (4.4-5).
- The standard should be multi-disciplinary, and all actors should be invited to comment (3.3).
- Scientific evidence should be used as reference, instead of political willingness (4.5.1).
- The standard needs to have test and methods that are reasonable, credible, scientific, that avoid lengthy litigation and that are internationally accepted (4.2.3-4, 4.5.1 and 4.4-11).
- The standard should have clear objectives and guiding criteria (4.2).
- The standard should generate data to be used for better public policy (4.4-1).
- Accountability for non-compliance should be prosecuted and enforcement should be possible rather than a good wish (4.2.4-2 and 4.4-2).
- The standard should assess the heterogenicity of the water bodies and allow for progressive technology to be incorporated (5).

4.4 Institutional Challenges

Government officials identified six main challenges associated with institutions that handle hydrocarbon contamination matters and the required EQS for its management. Orellana [14] from ASEA identified the first four challenges, while Ruiz [17] from SEMARNAT identified the last two; comments from non-government experts are provided where appropriate.

1) Statistics

“In Mexico there is no open access network for environmental incidents” [10], contaminated sites or information about the economic cost of remediation.

According to SEMARNAT, the data collection for contaminated sites was finished in 2011, however the National Inventory for Contaminated Sites (SISCO) only publishes the number of contaminated sites per state, it does not provide location, contaminants, or affected environmental media [70].

Environmental regulations require that responsible parties communicate with the environmental authority when a spill larger than 1 m³ reaches natural soil, however none is specified for water spills. Several experts [1, 5, 10, 14, 17] believe that the standard should incentivize to report any spill in waters, even without a fine, in order to generate statistics about incidents and have better tools for insurance coverage and public policy. The generation of a reliable inventory of environmental contaminated sites should not only depend on government entities, but also on Industry, especially now that PEMEX is not the only O&G operator [14].

SEMARNAT does not have information about the real cost for a remediation. From capital expenditure, to operation and maintenance, the authority is ignorant in real world remediation cost. As such, Regulatory Impact Assessments (MIR) are prepared with ballpark numbers and not educated guesses [17].

Once statistics are available, both government and industry can improve its performance. “[Authorities] need to learn to regulate with big data... public policy needs not to be anecdotal, but aggregated” [14]. Thus, “[r]egulation focused on information gathering can achieve major benefits by raising corporate awareness” [74].

2) Contamination attributability

“In Salamanca¹⁸ you have an assortment of industries including hydrocarbon, chemical, agriculture, textile, and all contributed to the water contamination. But even do contamination is evident, it is complex to trace back who polluted” [14].

¹⁸ One of the main oil refineries from the country is located in Salamanca, Guanajuato.

Due to the polluted conditions of Mexican aquifers and rivers, an environmental spill may not initiate contamination, but rather may exacerbate it. As such, the standard should be able to cope with baseline contamination and deal with joint liability matters (section 4.5.2-7).

3) Common funding

The Supreme Court ruled in favour of PEMEX in *Amparo Directo 9/2017* [57], holding that operators of the pipelines are not responsible for the payment of remediation services associated with contamination generated by hydrocarbon theft. As such, there is no direct responsible party for the hundreds of spills associated with such theft (section 2). To solve this problem, it is suggested to “pay in advance the life cycle assessment of the environmental impact” [5], using a compensation system based in funds, as the one used in the maritime environment [11]. In such a way, the ‘owner of the molecule’ will pay the government a small fee for each O&G product transported via pipeline, generating a fund that would cover remediation cost from illegal hydrocarbon theft.

4) Third-party certifications

“It is impossible and undesirable that the public bureaucracy grows proportionally to industry” [14]. Evangelista [6] and Orellana [14] identify that the law should be modified to allow for a certified third party, known as *Unidad de Verificación* or UV, to certify that a remediation has been conducted in compliance with applicable laws. This outsourcing of a portion of the remediation administrative process will reduce the time to remediate, and could solve the human resources quantity and quality issues that the authorities face [14] (sections 4.4-8 and 4.4-9).

Regarding this matter, Ruiz [17] identifies that the Mexican Constitution would need to be modified to allow an UV to supervise and authorize remediation.

5) Government framework

Ruiz [17] indicates that the legal framework under which the Mexican authorities operate differs greatly from Europe and USA, and as such Mexico has some limited ruling capabilities. In other latitudes, authorities have the capacity to regulate and enforce using technical criteria, and the flexibility to decide what is best. In addition, there is a trust system based on professional certifications that enables all actors to operate professionally (section 4.4-4). However, Mexico lacks such professional certification systems and authorities are limited to

do what the law dictates. As such, an environmental permit can be issued, but it is very limited when compared to other jurisdictions [17].

Ruiz [17] also indicates that the enactment of the hydrocarbon and heavy metals soil remediation standards were conducted in such a way to force Mexican remediation companies to emerge. The environmental authorities did not want international experts to copy remediation process from Europe and USA, as the modus operandi from environmental authorities in other latitudes greatly differs from Mexico [17], as previously identified (section 4.2.4-2)

The main problem in matters associated with water contaminated with hydrocarbons is not the missing remediation standard, but the blurry regulatory framework and the divided responsibilities between CONAGUA's different departments, SEMARNAT, ASEA and PROFEPA. In addition to this, the institutional design for ASEA is atomized, as such the government officials from ASEA have no experience and are unable to negotiate with large O&G companies [17] (sections 4.4-8 and 4.4-9). The blurry responsibilities of the different agencies dealing with water contamination, inadequate communication, and different financial resources among authorities are some of the challenges cited by the literature for multi-agency cooperation [72]. As Monsalve [11] indicates, "when there are several institutions involved in a process, it is fuzzy for the polluter and the victims" [11].

6) Authority liability

As discussed in section 3.4, ASEA has been designated the responsible authority for the enactment of a hydrocarbon contamination water quality standard. The reason for this designation is that SEMARNAT initially proposed a water quality standard based only in hydrocarbon contamination, without considering all other "emerging contaminants" [89]. However, if contamination is analysed as an integral problem, including volatile organic compounds, halogenated compounds, hormones, and any other non-hydrocarbon pollutant, CONAGUA is the responsible party for the analysis of a water remediation standard.

Ruiz [17] indicates that CONAGUA is not willing to enact any water quality standard due to potential liabilities associated with this. According to Ruiz [17], one of the main objectives of a standard is to legally determine when a site is classified as contaminated. Therefore, enacting the standard would allow classification or categorization of all currently polluted

aquifers and rivers. As such, a citizen or an NGO could take a sample from the Salamanca basin, and due to the presence of free product in the area [67] and its health implications, they could potentially sue CONAGUA (and perhaps ASEA also) due to omission in severe human health risks matters [17].

Non-government experts identified five additional institutional challenges.

7) Work load

The fact that the jurisdiction of gas stations was transferred from the States to ASEA means that “ASEA is not focused on the important matters [such as remediation], but instead is loaded with low-value added work” [1]. ASEA has almost 18,000 regulated companies, from which approximately 12,000 are gasoline stations and 3,300 liquid petroleum gas (LGG) stations [93].

Section 4.2.5 already discussed the work load that CONAGUA would have in case an EQS is enacted.

8) Human resources quality

“The quality of human resources [within environmental authorities] has diminished, the new people has no idea of the matter [remediation], except from what they saw in school... decisions are being made based on a textbook, there is no creativity for the terms and conditions [of the remediation plans]” [9]. “Government officials don’t last in the positions, they jump to a new political position, and as such there are no real experts” [15].

From the 16 structured interviews, only 3 experts indicated that the environmental authorities, SEMARNAT, CONAGUA and ASEA, maintain the quality of human resources to attend Industry in water contamination matters.

Huerta [10] suggests that the standard enactment should include an obligation for adequate cross-sector training for upper and lower management environmental authority personnel. Upper management should understand the “real world markets” to be able to enact adequate standards, while lower management personnel should be trained in how to understand such standards. Hicks [15] further suggest that the standard requires adequate training for judges.

9) Human resources quantity

From the 16 structured interviews, only 1 expert indicated that environmental authorities maintain the quantity of human resources to attend Industry in water contamination matters, and the reason for that is because to his/her knowledge there are not a lot of water contamination cases.

10) Documentation chain of custody

“The environmental authorities do have some competent personnel, the issue is to make sure that they analyse your documentation, you need an adequate lobbying with the authority for that” [3].

In a remediation process there is no certainty as to who receives, analyses and approves the ERA or remediation proposal submitted. Industry is afraid to submit documentation that will be later analysed by a non-competent government official.

11) Social license

Social license “can be defined as a contractarian basis for the legitimacy of a company’s specific activity or project” [62], and although the term is more used in the literature for industrial operations, its principles also apply to government entities.

The social license requires legitimacy from all relevant stakeholders [62, 77], which in this case includes Mexican citizens, Industry, and academia. As expressed in the expert’s words:

- “A no further action certificate from the soil remediation standard means nothing to Mexicans, they don’t believe it is clean” [14].
- “Authorities does not have enough leadership to generate adequate standards, as such we are left behind in comparison with other countries” [13].
- “Having autochthonous standards is an improvement as a society, the quality criteria should be a bottoms-up approach generated by the organic research and development of the Mexican universities and local actors... it is needed a standard that generates confidence, and to import one quality criteria will not generate local confidence... using a Texas standard will only generate challenges (*amparo*) towards SEMARNAT... it is important how the criteria was reached, not only the criteria per se” [5].

4.5 Other Findings

4.5.1 Public Policy Options

Overall, experts believe that a standard which provides a reference table with water quality standards is the best public policy option for Mexico. The reasons for this 'command and control' approach are the institutional challenges already discussed in section 4.4, and the following additional reasons:

- Political winds

"I tried to have a meeting with a SEMARNAT official, and he kindly indicated his unavailability, as it was elections time" [10].

A new government administration may switch political objectives and the former public policy approach may not continue [1, 3]. Remediation techniques approved a couple of years ago may today be totally rejected, without a science base explanation, just because a new political administration is in power [4].

- Education

Training / education for government entities has been discussed, however, several other actors are involved in a remediation process and they also need training / education.

- "In Mexico we still need to regulate with command and control, we don't have the education to have the civil courage to solve the issues as they need to be solved" [9].
- "The NOM will educate Industry, it will expose it to the real cost of a remediation" [10].
- "Environmental lawyers should be trained in science matters, not only in legal procedures" [15]

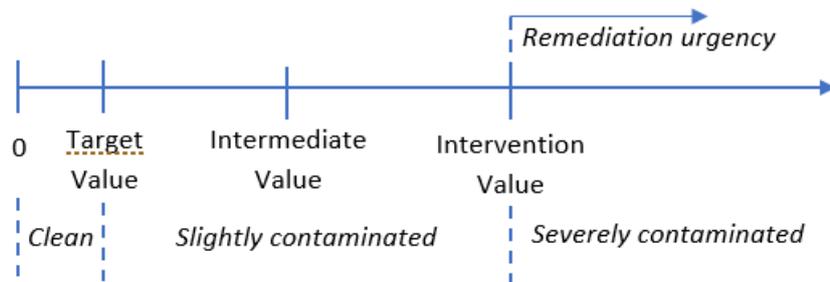
Nevertheless, three different or complementary public policy options were identified during the research.

- 1) Intervention value

Experts agree that the regulation should be based on risk [5, 7, 14, 15, 16, 17]. However, how the risk is framed and who calculates it (authority vs. responsible party) could change. Scenarios B and C classify the water in a dichotomous way, either as clean or contaminated, and leave little manoeuvre for instances where the contaminant concentration is slightly

above the remediation value (i.e. 205 vs. 200 mg/L).¹⁹ However, an approach based on intervention values, such as the one used in Netherlands [33], could also be enacted. Figure 2 shows the intervention value regulatory scheme [32].

Figure 2 Intervention value approach



Where

Concentration < Target Value; no further action

Target Value < Concentration < Intermediate value; minor potential restrictions

Intermediate Value < Concentration < Intervention value; ERA

Intervention Value < Concentration; remediation

Alfaro [7] suggest a similar approach into which the standard would identify if the water is considered contaminated or not, and then an ERA will determine the quality criteria needed.

2) Economic incentives

Neira [5] suggest that other economic public policy incentives could be considered, such as the case in Brazil where the stock market awards “extra points” to the stock of companies that disclose environmental assessments or secure gradual pollution insurance. The ultimate goal with this kind of incentives should be that Industry discloses pollution liabilities in the financial reports [5].

3) Land use

Ruiz [17] identifies that land use permits used for new developments could also be used to regulate contamination as done in other jurisdictions, and if that policy approach is used, the cadastral tax could serve for taxing contamination. A challenge for such a public policy approach is that water contamination migrates easily, contrary to soil contamination.

¹⁹ Refer to section 5 for a discussion of exemption mechanisms

4.5.2 Regulatory Modifications

Experts agree that the regulatory framework does not require enactment, modification or elimination of any law or regulation to be able to enact the proposed EQS. However, not modifying the current legal structure will mean “suffer[ing] the same pain as in the soil remediation standard” [14].

The following suggestions are what experts believe should be modified, added to the current regulatory scheme, or addressed during the policy design in aims to improve the regulatory system regarding water contaminated with hydrocarbons.

1) Regulatory structure

The Mexican regulatory framework includes several laws, regulations and standards in matters associated with environmental contamination. However, there is a great difference in how soil and water contamination are regulated. Soil contamination regulations include definitions, polluter responsibilities, sampling procedures, EQS, among other regulatory elements. On the other hand, water contamination is missing these.

As such, to provide a straightforward structure in the regulatory framework that regulates water contamination, experts suggest:

- The waste law (LGPGIR), which regulates soil contamination, should identify that water contamination will be regulated by the water law (LAN);
- The LAN should define water contamination, reference the enacted EQS, and establish the administrative procedure to follow when dealing with water contamination. The administrative procedure should identify which authority will approve the ERA and remediation plan, and into what timeframe will be approved.
- The environmental accountability law (LFRA) should be modified to expedite the courts' administrative process in remediation matters. The law as of today “judicializes environmental matters” [14], which prevents a prompt response.
- The Organic Law of the Federal Administration (*Ley Orgánica de la Administración Pública Federal*) and the ASEA law (*Ley de la ASEA*) should be modified to create an adequate institutional framework for water remediation issues [17], as discussed in

section 4.4-5. If such laws are not modified, authorities will attempt to generate institutional framework within standards, which is not adequate public policy.

- The Constitution should be modified to allow third-party certification companies to authorize remediation plans and to issue no further-action certificates [6, 14, 17] as discussed in section 4.4-4.

2) Environmental definitions

Mexican regulations define contamination as the presence of one or more contaminant, or a combination of those, that generates an ecological disequilibrium.²⁰ As such, contamination is defined as a condition, not as a process.

The definition of contamination should be changed to reflect the fate and transport of pollution processes, and the uncertainty associated to dose-response science in ecological disequilibrium. As Sosa [4] indicates, “Mexico’s law does not define gradual or sudden contamination, it only specifies that if you pollute, you pay... and that is not how environmental insurance works”.

An integral definition of contamination will provide more legal certainty, will allow an easier transfer of risk towards the insurance policies, and will help victims to secure compensation.

3) Remediation Deadlines

The EQS for soil contaminated with hydrocarbons was enacted in 2002, however it did not specify a timeframe for compliance [4]. As such, sites that were contaminated before the enactment of the standard are still under operation, and no remediation has been conducted; such as the PEMEX refineries. The same situation exists for the EQS for heavy metals contamination.

As previously identified, Mexican aquifers are already contaminated with levels that threaten the health of communities and ecosystems. Also, due to the migration of pollution, water contamination usually generates greater impacts, especially in fishing communities [11]. Therefore, the EQS should provide a timeframe for the remediation of existing contamination, and not only future contamination. Mexico could mimic the strategy for remediation

²⁰ Ley General del Equilibrio Ecológico y Protección al Ambiente, article 3, section VII

timeframe established by Netherlands [32], where an ecological priority ranking dictates the remediation hierarchy timeline.

4) Monopolies

Industry tries to avoid remediation processes due to its high cost and the burdensome administrative process it requires. The high cost is generated due to a variety of reasons: the long-time professional services of consultants and lawyers are required, sampling requirements (number and type of analysis), the existence of few remediation companies due to the low demand of services, and the high cost of laboratory services.

When the soil EQS were enacted, several commercial interests were vested; especially in respect of the laboratories [4], which created a market monopsony. In recent years the analytical laboratories that service hydrocarbon contamination sampling have merged [90], and currently there is a dominant player: Intertek + ABC. The enactment of water EQS should carefully avoid the generation of monopsonies or monopolies (section 4.2.4-2) that could drive the market via price control tactics.

5) Social Cost

The lack of environmental regulation associated with water contamination incentivizes Industry to not remediate; therefore, almost any contamination scenario is converted into a full social cost [12]. According to the National Statistics Institute, the economic cost²¹ of water quality degradation in 2016 was valued in \$2.6 thousand million US dollars (2016) [38], an externality that is being accrued every year towards future generations.

International experience in oil pollution has shown that the social cost is not evenly widespread among the whole society. On the contrary, some of the most vulnerable members are the ones that carry higher costs. For example, a fishing community that conducts its economic activity in a polluted region has a larger social cost than a neighbourhood in downtown Mexico City.

The enactment of the EQS should also include regulatory modifications using the Coase theorem to allocate 'the ownership' of the water resources to the victims, in such a way that the victims are not required to prove negligence from the polluter, and strict liability is

²¹ Social cost is always higher than the economic cost [73].

enforced [11]. The social cost of a contamination cannot be eliminated, however, with such liability regime, the social cost of the most vulnerable members of the society will be partially relief.

6) Emergency Plan

“We should have a classification for the highly susceptible areas to be impacted [by hydrocarbon contamination]” [15].

Mexico already has an EQS for hydrocarbon soil contamination, which identifies sampling protocols, laboratory analysis and soil quality criteria; and an emergency plan for oil spills in marine waters, in which relevant actors are identified with specific responsibilities detailed [43]. However, no guidelines or plan is available for continental water contamination.

The enactment of the EQS should also include regulatory modifications to require the creation of a national contingency plan for hydrocarbon contamination in continental water. Such a plan should, among other elements, identify high-risk areas for continental water contamination (i.e. major pumping stations near a river or pipelines that cross a river); identify priority areas where an environmental baseline is required (section 4.5.2-7); define the circumstances into which the polluter is required to install a local support office [11]; and define coordination efforts among federal and state authorities. The preparation of such plan will allow to better react during an environmental emergency.

7) Environmental Baseline

ASEA requires the preparation of environmental baselines in some O&G activities such as well construction, development and exploitation. In addition, an environmental impact assessment is required for the construction and operation of O&G pipelines. However, none of the regulatory requirements provide adequate information for continental water high-risk contamination areas.

Having an environmental baseline will allow a “guide for where you want to go” [3], and to “identify the [flora and fauna] species present in the area before any spills” [11], therefore facilitating remediation. The baseline will also “provide additional information that could reduce the cost of environmental insurance” [5]. Furthermore, the environmental baseline could “work as a public policy instrument between a market instrument and an environmental

impact assessment to regulate land use change” [17] (section 4.5.1-3), and “it can be used to guide the national water quality public policy” [3].

The enactment of the EQS should also include regulatory modifications to construct one national inventory of environmental baseline conditions for continental water contamination high-risk areas (section 4.5.2-6). The regulatory modification could also require an environmental baseline for a M&A of an O&G property, as USA does with the Comprehensive Environmental Response, Compensation, and Liability Act [92] (section 4.2.4-3).

5. Future research

The research shows that experts agree in several issues, including that Mexico will benefit from enacting a water EQS for hydrocarbon contamination. However, in certain standard design criteria or public policy matters, experts differ in their opinions. The following paragraphs explain the issues that require further research to reach a conclusion.

Experts do not agree on the magnitude or threshold of the environmental incident that will trigger the need for water remediation. Soil contamination regulations establish that remediation is required (preparation of remediation program) when there is spill larger than 1 m³. However, when experts were inquired about the minimum spill volume that would trigger water remediation, very different answers were obtained. Some experts support that any water spill will require remediation; some support a remediation requirement based on a minimum volume spilled by chemical (i.e. 10 litres of gasoline, but 1 litre of Toluene); others support a scheme that does not require any remediation if emergency actions eliminated risks to adjacent properties or external personnel; while others support that remediation should be triggered based on the future use the polluted water will have (drinking, industrial, etc.). International approaches also include intervention values (section 4.5.1-1), which determine a remediation is required based on laboratory Method Quantification Limits (MQL), background limits, and concentration above actions level [71]. Due to the lack of consensus among experts as to when a water remediation should be triggered, further research in contaminant fate and transport science, and toxicological and epidemiological effects research needs to be conducted to properly identify the optimal water remediation triggering elements.

Experts also do not agree on how the EQS should classify continental waters. Mexican regulations divide waters using four different approaches:²² 1) future water use such as domestic or industrial; 2) water availability, from scarce to plenty; 3) water price, ranging from cheap (domestic use) to expensive (habitat protection use); and 4) water quality, ranging from pristine to contaminated. Mexico's soil EQS uses a future use approach when dealing with contamination (residential, commercial and industrial). International water EQS establish remediation standards dependant on future water use. Expert preferences on how the EQS should classify the water is towards future water use as the main classification criteria; however, experts indicate that fewer categories than the ones regulated should be considered (currently 10 uses are regulated). Therefore, further research on

²² RLAN = Regulation of the National Water Law (*Reglamento de la Ley de Aguas Nacionales*) article 2 and LDF = Federal Fees Law (*Ley Federal de Derechos*) articles 224, 224 and 278-A.

hydrogeology basins and toxicological effects of hydrocarbon contamination is required to properly set the water classification into the EQS.

One issue mentioned by several experts, and which did not reach a clear conclusion, was the circumstances under which the EQS would need an exception. Some remediation techniques may generate larger ecological damage than the sole presence of hydrocarbons. Examples of this situation are the pressure or manual washing operations conducted in mangroves, where the washing damages the feeble network of branches more than the sole hydrocarbon sheen. Further research needs to be conducted to identify the circumstances into which the EQS should be exempted or not enforced, if any. Scenarios identified during the interviews include shallow brackish water contamination, or remediation (further of water skimming) into low energy ecosystems as marsh, swamps, water-meadows, or mangroves.

In addition, several experts identified that the EQS should include a wider range of chemicals, such as metals, hormones, antibiotics and the like (known as emerging contaminants), or to be more integral and include food security issues. The original scope of the assessment focused purposely and exclusively on hydrocarbon contamination, and as such, no further contaminants or aspects were considered during the research. The reasons for the limited scope are the lag of Mexican regulations in water matters, the main contaminants spilled, and the energy reform. However, Grant [9] identifies that in addition to BTEX and PAH, scenario C should also had included gasoline oxygenating agents, specially methyl tert-butyl ether (MTBE) and tert-Amyl methyl ether (TAME). According to the NOM-016-CRE-2016 [58], Mexico allows gasoline to contain MTBE, TAME, but also ethyl tertiary butyl ether (ETBE) and diisopropyl ether (DIPE). MTBE has been widely banned in the USA, due to its potential groundwater contamination potential and carcinogenic characteristics [59], although the rest of the world appears to continue its use, including the European Union [60]. Based on the chemical contents of Mexican gasoline and diesel, it appears all the significant soluble chemicals are considered in the assessment [94], except for the already mentioned oxygenating agents. However, it is uncertain how experts would have modified their answers if gasoline oxygenating agents had been included in scenario C. Further research would need to be conducted to assess if the inclusion of MTBE and other oxygenating agents would modify the experts' preferences into which scenario would benefit Mexico the most.

The last issue identified that requires further research is how to design an adequate government framework to deal with hydrocarbon contaminated waters. As indicated in section 4.4-5, the main challenge in matters associated with water contaminated with hydrocarbons does not appear to be

the missing remediation standard, but the blurry regulatory framework and the divided responsibilities between CONAGUA, SEMARNAT, ASEA and PROFEPA. A detailed research on the four environmental authorities' structures, budget, legitimacy and legal responsibilities is required to construct the architecture of a solid environmental institutional framework that will allow to adequately regulate a complicated topic as the one assessed.

6. Conclusions

The O&G industry, and more specifically the downstream activities associated with fuel management, are one of the main soil and water polluting activities in Mexico. Before the energy reform only PEMEX managed such activities, and currently international players are slowly getting in the market. As such, a whole new era in O&G is being experienced, which generates a great political momentum for the enactment of hydrocarbon related regulations.

The environmental authorities have documented the need of an EQS for water contamination, which includes hydrocarbons, but also other pollutants. However, no regulatory analysis has been conducted for the enactment of such standard by the authorities, and there is no academic research dealing with the matter. There is a gap in knowledge about the water EQS in Mexico, and this research is the first attempt to deal with the matter.

Experts believe that Mexico will benefit if water contamination regulations are drafted, specifically if a water EQS for hydrocarbon contamination is enacted. The enactment of such a standard is expected to generate cost and time savings in remediation, to increase legal certainty, human health and ecosystem health, and to generate other indirect industry benefits. In addition to having a standard that allows us better to deal with environmental matters, it does not appear that environmental authorities have other indirect benefits.

Experts agree that that the most important criteria to be considered when drafting environmental quality standards are Human Health and Ecosystem Health, which is consistent with international water EQS criteria ranking.

There is no need to enact or modify laws and regulations to enact a water EQS for hydrocarbon contamination. However, without modifying the current regulatory framework, the proposed standard will face the same burden that the soil EQS has, and incentives for not remediating will continue existing.

The main challenge that Mexico faces for an adequate management of water contamination is not the missing water EQS, but the complex and blurry institutional framework that deals with the matter. SEMARNAT, ASEA, CONAGUA and PROFEPA have significant institutional architecture and operative challenges to properly deal with the matter. Potential authority liability associated with the enactment of the proposed standard is a significant inhibitor for the regulatory process.

Relevant criteria for water contamination matters are endogenous, such as are the relevant factors within the criteria. As such, a step wise approach that tries to solve one factor or one criteria will not solve the problem, Mexico requires a holistic solution to the problem that deals with cost, response time, legal certainty, authorities modus operandi, human resources and industry incentives. Therefore, further research is required in several topics to properly design a solution for the problem, especially in authority architecture.

The enactment of one hydrocarbon contamination EQS is a significant progress towards Mexico's sustainable development, however, Mexico will still face great challenges in contamination matters from other type of pollutants.

The refusals to participate by several stakeholders does not appear to bias the results obtained. As indicated before, no prior academic research has been conducted; therefore, the refusal to participate by academic institutions is not expected to have a significant impact. The participation refusal from the Health Secretariat does not generate a great impact as the Human Health criteria is no further analysed, and even if analysed, the ERA would consider the health impacts. The refusal from CONAGUA could be considered as relevant in the matter, however information provided by SEMARNAT and ASEA cover in great detail the CONAGUA responsibilities. The refusal from PEMEX does not significantly impact the results as industry that is responsible for hydrocarbon contamination was interviewed. Nevertheless, the fact that the gasoline retail distributors did not participate do hinders the assessment in a specific topic: risk analysis for mergers and acquisitions in the O&G field; this as before the energy reform only PEMEX maintained those services.

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²³ Including images, tables, notes and page numbers, but excluding bibliography and dissertation declaration.

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