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Russia Pipeline Oil Spill Study

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Preface

Many countries have a number of pipeline networks for the transportation of crude oil and cc gas. In most developing countries, there is a lack of proper standards and guidelines for the design, construction, and operation of these pipelines, and inadequate procedures and regulations for addressing environmental concerns related to spills. Furthermore the poor financial situation in several developing countries prevents proper maintenance and operation of the pipelines, and this makes it difficult to maintain proper contingency facilities to combat oil spills when they occur. Invariably, oil spills in developing countries that are caused as a result of pipeline ruptures are not addressed promptly and efficiently and as a result, often create major environmental disasters. To reduce the frequency and the consequences of oil spills, it is of great importance that appropriate standards, regulations, risk management procedures, and so forth are developed based on existing regimes and experience in the operation of pipelines in industrialized regions such as North America and Western Europe.

In November 1997 the World Bank awarded Det Norske Veritas (DNV), a consulting firm from Norway, a contract to undertake a desk study of the characteristics of oil pipelines and the causes of ruptures; and also to evaluate the legal and regulatory frameworks being applied in Russia and states of the former Soviet Union (FSU) for responding to oil spills and the environmental consequences of these spills. About 113 major pipeline spills in several climatic regions of FSU were studied. The results from the study provided a better understanding of the causes of oil pipeline spills in these countries. The knowledge could then be used to develop a set of guidelines and standards for safe operation of pipelines, and for implementing preventive and mitigation measures to minimize the impact of future spills in the FSU and other developing countries.

Acknowledgements

The report is a desk study that was performed by Det Norske Veritas (DNV), a consulting firm from Norway, during the period of December 1997 to October 1998, under a Norwegian Consultant Trust Fund managed by the Energy Sector Management Assistance Programme (ESMAP). The Task Manager for this study is Akin Oduolowu, Principal Energy Specialist, Oil and Gas Policy Division (COCPO), and secretarial assistance was provided by Carmen Pineda (COCPO).

Abbreviations and Acronyms

COGO	Canadian Oil and Gas Operations Act
COCPO	Oil and Gas Policy Division (World Bank)
CONCAWE	European Oil Company Organisation for Environment, Health and Safety
CSA	Canadian Standards Association for Pipelines
DNV	Det Norske Veritas
EIL	Environmental Issues List
ESMAP	Energy Sector Management Assistance Programme
FSU	Former Soviet Union
FOH	Norwegian Marine Pollution Research and Monitoring Programme
Gazprom	Russia Oil and Gas Company
GOST	Gas and Oil Pipeline Standards (Russia)
HCB	Hazardous Cargo Bulletin (United States
IChemE	Institution of Chemical Engineers Accident Database (United Kingdom)
IUCN	International Union for the Conservation of Nature
IUPN	International Union for the Protection of Nature
LCR	*Lloyd's Casualty Report* (London, United Kingdom)
LPDS	Line Production Dispatch Service
MChS	Ministry of Emergency Situations and Mitigation of the Results of Catastrophes (Moscow, Russia)
MFL	Magnetic Flux Leakage
MHIDAS	Major Hazard Incident Data Services Database(United Kingdom)
MPSM	Main Pipeline Security Measures
NEB	National Energy Board (Canada)
NGDU	Oil and Gas Production Unit (Russia)
OGJ	Oil and Gas Journal
OGSR	Oil and Gas safety regulations
OPR	Onshore Pipeline Regulations of Canada
OSCPP	Oil Spill Contingency Pipeline Plans
OSIR	Oil Spill Intelligence Report (United States)
PIMS	Pipeline Integrity Management Systems
RNU	Regional Oil Directorate (Russia)
SFT	State Pollution Control Authority
TSB	Transportation Safety Board of Canada
WSF	Water Soluble Fraction

Executive Summary

1. Pipelines have become an efficient means of transporting liquid and gaseous materials (particularly crude oil, petroleum products, and natural gas) for long distances over land, underground, and sub-sea from production locations to the market. When properly maintained and operated, pipelines provide the transporters the advantages of economy of scale, because an increase in volume of materials being transported can be effected cheaply through an increase in pumping pressures. Pipelines therefore have become competitive and complementary to other forms of transportation (such as ocean tankers, rail, and road trucks) for oil and gas.

2. Major pipelines can be found around the world installed sub-sea, buried underground, or over land. However, a ruptured pipeline has the potential of doing serious environmental damage since most of the products being transported are environmentally hazardous if spilled. The potential for significant spills increases as the world's existing infrastructure of pipelines ages; additional lines are added; and as oil and gas exploration and production activities shift from the more established and better environmentally monitored areas in North America and western Europe to frontier areas in less developed parts of the world. There is therefore a need to establish appropriate standards and guidelines in the design, construction, and maintenance of pipelines in different environments. Providing these guidelines is complicated by the fact that most developing countries have not established proper guidelines and standards for the design, construction, and operation of major oil pipelines. Nor have most developing countries established appropriate regulations or operating procedures for addressing environmental concerns related to spills. In addition, some of these countries lack the necessary maintenance culture or financial strength to ensure that oil and gas pipelines are kept in good working condition at all times.

3. Although pipeline oil spills cannot be completely eliminated, their frequency and severity can be reduced by the following measures:

?? setting adequate standards and regulations and enforcing them; and

?? establishing proper pipeline risk management.

4. Risk of pipeline ruptures is a function of several factors including mechanical problems, corrosion, third-party activities, operational variables, and climatic or environmental changes. Comprehensive procedures to address these factors can mitigate the probability or frequency of spills and the severity of the resulting environmental damage. Rapid response contingency plans can mitigate the consequences of hazardous incidents.

5. Establishment of appropriate and effective mechanisms for better management of the pipeline infrastructure in developing countries could be facilitated by a thorough understanding of the following conditions:

?? causes, locations, and details of major pipeline oil spills;

?? clean-up costs;

?? prevention measures in place or that should logically be put in place;

- ?? local laws, regulations, and guidelines addressing environmental aspects of oil pipelines; and
- ?? oil spill emergency action plans.

6. In order to gain insight into oil pipeline spills in an operational environment that is similar to several developing countries, this study was designed to use the historical accounts of some of the spills in FSU to develop the knowledge base on oil spills. The knowledge is then used as basis for developing preventive and mitigative measures to reduce and minimize the impact of future spills. The countries of the former Soviet Union (FSU) have over 84,000 kilometers of pipelines of varying ages and diameters for crude oil transportation. The FSU has experienced several oil pipeline ruptures and spills.

7. Det Norske Veritas, a consulting firm from Norway, was employed in 1997, under a Norwegian Consultant Trust Fund managed by ESMAP, to undertake a desk study titled Pipeline Oil Spill Prevention and Remediation in the FSU. This study provides a set of criteria for developing preventive and mitigative measures for reducing occurrence of pipeline oil spills in developing countries.

GENERAL OBJECTIVE OF STUDY

8. The general objective of this study is to develop a knowledge base on the causes of oil pipeline spills and to recommend preventive measures for reducing the occurrence of oil spills and mitigation measures for addressing the environmental impact of the spills. The intention is that the results of this study would be used to generate greater awareness, interest, and knowledge within the World Bank and its member countries of the potential for pipeline oil spill damage and the need for preventive and mitigating actions and investments. More specifically, components of the study include the following:

- ?? Study the historical oil pipeline spills.
- ?? Assess oil pipeline rupture risk and recommend measures to reduce oil spill probability and impact severity.
- ?? Identify best practices in developed countries and recommend ways of translating these to areas having inadequate arrangements for combating oil spills and mitigation of their effects.
- ?? Promote establishment of regulatory and monitoring systems.
- ?? Promote the development of incentive systems to encourage the oil industry to minimize environmental degradation arising from oil pipeline spills (in particular).

9. In order to achieve the above goals, the components of the study are grouped into four main tasks:

- ?? collection of data on pipeline network of FSU;
- ?? analysis and risk assessment of the pipeline network data;
- ?? review of the legal and regulating regimes of FSU and comparison of these regimes with those of Canada; and

?? recommendations for strengthening the regulatory and monitoring systems in FSU.

10. Data Collection Several relevant sources were contacted in the FSU countries for data on crude oil spills from pipelines. The data search identified *113 major crude oil spill accidents* during the period 1986–96 (inclusive). The 113 recorded accidents are widely thought to represent only a fraction of the total number of spills that have actually occurred. Independent but unconfirmed sources indicate that some pipelines have experienced several hundred smaller spills due to the poor condition of the pipes and erratic operating procedures. Nevertheless, the 113 reported accidents give a good picture of the causes of pipeline ruptures and containment methods in the FSU. Furthermore, the 113 accidents used in this study include those that had great impact on the environment or economy, and for which most of the cleanup and recovery work has been monitored, carried out, or financed by foreign countries or organizations. ”

11. The data used involves crude oil spills from major pipelines with diameters greater than 15 inches. Access to data was very constrained because information on most oil spills is not publicly reported in Russia and the FSU. Such information belongs to the owner/operators of pipelines and is in a non-systemized format which makes retrieval difficult.

Pipeline network data

12. Although Transeft is the main organization in Russia responsible for crude oil pipeline transportation, the data used were obtained from a digital map of trunk oil pipelines residing on a CD-ROM prepared by the Scientific Technical Centre of Means, Communications, and Transportation (NTT’s “KOMTRANS”), Moscow, Russia. From this data was extracted, the oil spill frequencies, i.e. number of spills per kilometre and year, with special emphasis on diameter, location and length for the respective pipelines.

13. As of 1998, there was approximately 84,000 kilometers of pipeline in the FSU, of which about 90 percent has a diameter greater than 20” inches. About 64,000 pipeline kilometers, or 76 percent of the total, are located in Russia. Table 1 shows the distribution of pipelines between the various states of the FSU by pipeline diameter.

Table 1. Pipeline Kilometers by Location (State) and Diameter Class

Location	*Diameter class (inches)* *<15*	*15–22*	*23–32*	*>32*	*Total km by location*
Azerbaijan	160	183	403	—	746
Belarus	—	95	2,499	335	2,929
Georgia	22	423	—	—	445
Kazakhstan	256	2,113	3,285	2,597	8,251
Latvia	—	—	753	—	753
Lithuania	—	—	606	—	606
Russia	1,985	16,156	23,157	22,514	63,812
Turkmenistan	361	358	185	—	904
Ukraine	28	939	2,874	698	4,539
Uzbekistan	400	—	670	—	1,070
Total km by diameter class	3,212	20,267	34,432	26,144	84,055

— = Not available.

— *Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.*

DATA ANALYSIS

14. Analyses of the 113 reported accidents were undertaken in accordance with criteria of the European Oil Company Organisation for Environment, Health and Safety (CONCAWE). The results are shown in Tables 2 and 3.

Likely causes of pipeline ruptures

15. According to internationally accepted CONCAWE classifications, the following factors or combination of factors could cause pipeline ruptures:

Mechanical failure can occur either during construction as a result of negligence or the utilization of poor quality pipeline materials, or as a result of structural deterioration of the pipeline material (wear-and-tear) due to age. Generally, the older the pipeline, the greater the probability of mechanical failure.

Corrosion of pipelines occurs both internally and externally, and often results from the lack of anticorrosion coatings.

Operational errors include both system failure and human errors including lack of adequate maintenance.

Third-party activities can damage pipelines, whether accidental, malicious (such as sabotage), incidental, or acts of war.

Natural hazards to pipelines include ground surface subsidence, river flooding, wind erosion, and rapid changes in temperatures.

Table 2. Number of Oil Spills by Location (State) and Cause: FSU 1986–96

	Cause of spill						
Location	***Mecha-nical failure***	***Corrosion***	***Opera-tional error***	***Third party activity***	***Natural hazard***	***Unknown***	***Total spills by country***
Azerbaijan	1	—	—	1	—	1	3
Belarus	—	—	—	—	—	1	1
Kazakhstan	—	—	—	—	—	1	1
Latvia	1	—	—	1	—	—	2
Russia	26	13	7	15	3	37	101
Ukraine	3	—	—	—	1	1	5
Total spills by cause	31	13	7	17	4	41	113

—Not available

*Note:*Cause categories are according to CONCAWE definitions.

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997

16. As Table 3 shows, the highest number of spills occurred in Russia (89.4 percent) and the main ruptures (about 39 percent) occurred in pipelines with diameters ranging from 23 "to 32 inches". Figures 1 and 2 show the distribution of causes of pipeline failures in FSU and Western Europe. During 1986–96, mechanical failures and failures due to third-party activity were most prevalent in FSU, while corrosion effect and third-party activities were the main causes of pipeline failure in Western Europe. The prevalence of failures due to third-party activities further emphasizes the importance of establishing effective regulatory and monitoring mechanisms in countries for pipeline operations.

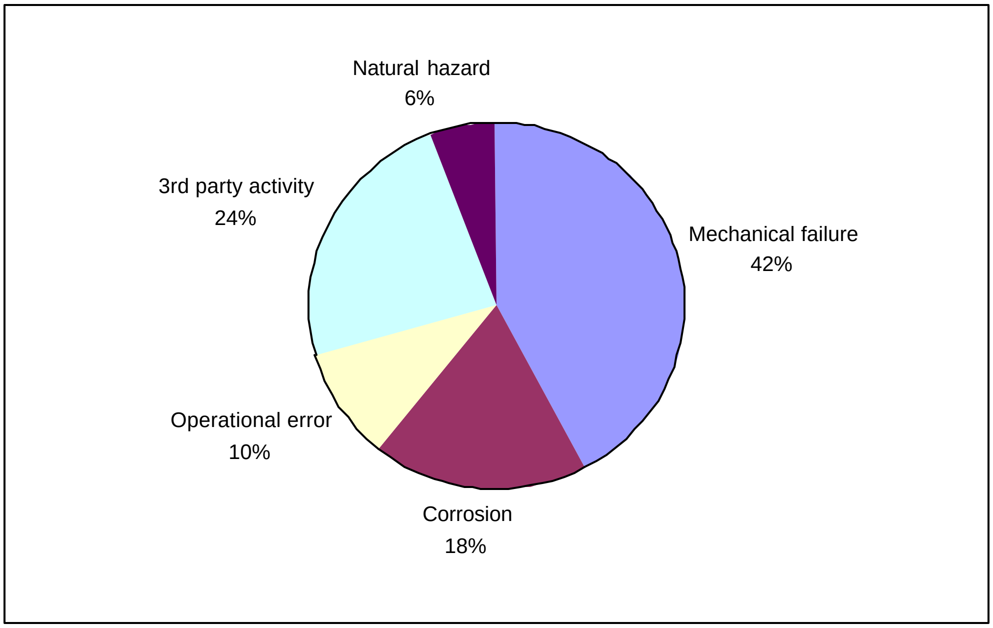
Table 3. Number of Oil Spills by Location (State) and Diameter Class: FSU (1986–96)

	Diameter class (inches)					
Location	8–14	15–22	23–32	>32	Unknown	*Total spills by country*
Azerbaijan	—	—	—	—	3	3
Belarus	—	—	1	—	—	1
Kazakhstan	—	—	1	—	—	1
Latvia	—	—	2	—	—	2
Russia	8	34	36	18	5	101
Ukraine	—	—	4	1	—	5
Total spills by class	8	34	44	19	8	113

— = Not available.

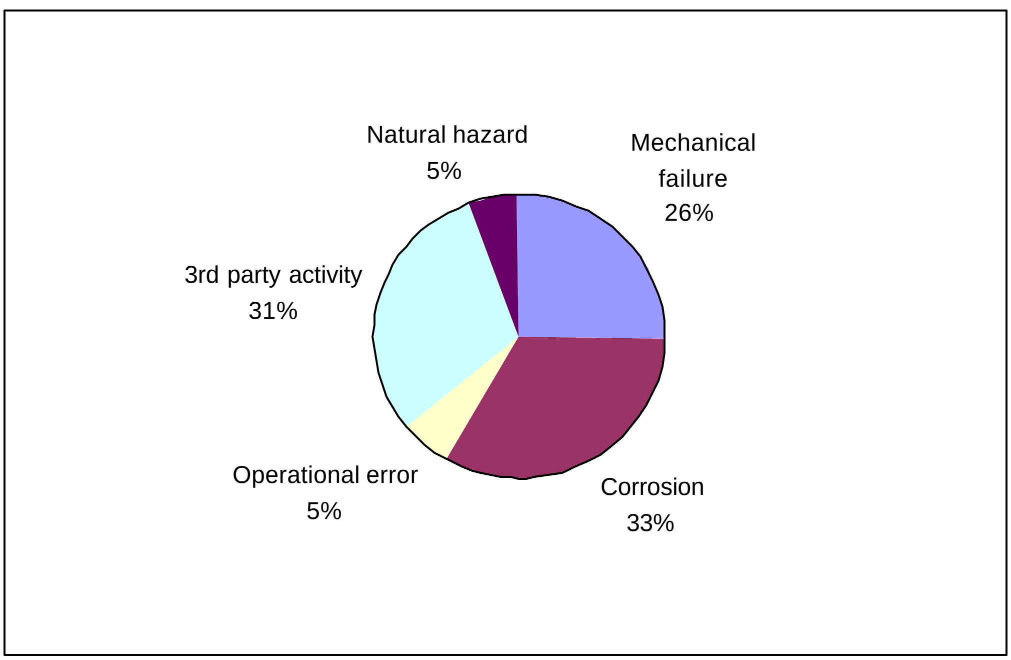
Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Figure 1.Distribution of Oil Spill Causes in FSU, 1986–96



Source: *Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997*

Figure 2. Distribution of Oil Spill Causes in Western Europe, 1986–96



Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

RISK ASSESSMENT

Climatic effect on pipeline ruptures

17. Climate has measurable, significant impact on the durability of pipelines. For pipelines installed across regions with different climatic conditions, adequate compensation must be made for the effects of temperature and climatic changes both in the specifications of the pipeline and how the pipeline is laid. The effect of climate to pipelines in FSU is briefly reviewed below.

18. The FSU may be divided into two major geographic/climatic regions, with the main separating feature being the permafrost: (1) the Arctic and tundra region, and (2) the region south of the tundra and the Arctic Circle. Northern Russia is made up of enormous steppe-like tundra and forested areas (*taiga*) characterized by large, continuous, and relatively intact habitats (that is, wilderness areas). The Arctic ecosystems are characterized by short growth seasons, low number of species (but large populations), and simple food webs. This results in long restitution periods and processes, making the region vulnerable to human impact. The large rivers contain important and vulnerable species and resources, such as the sturgeon and the large estuaries and deltas important for migratory birds. Several of the rivers originating from the north and draining to the south empty into closed or vulnerable water bodies such as the Black Sea, the Caspian Sea, and the Aral Sea.

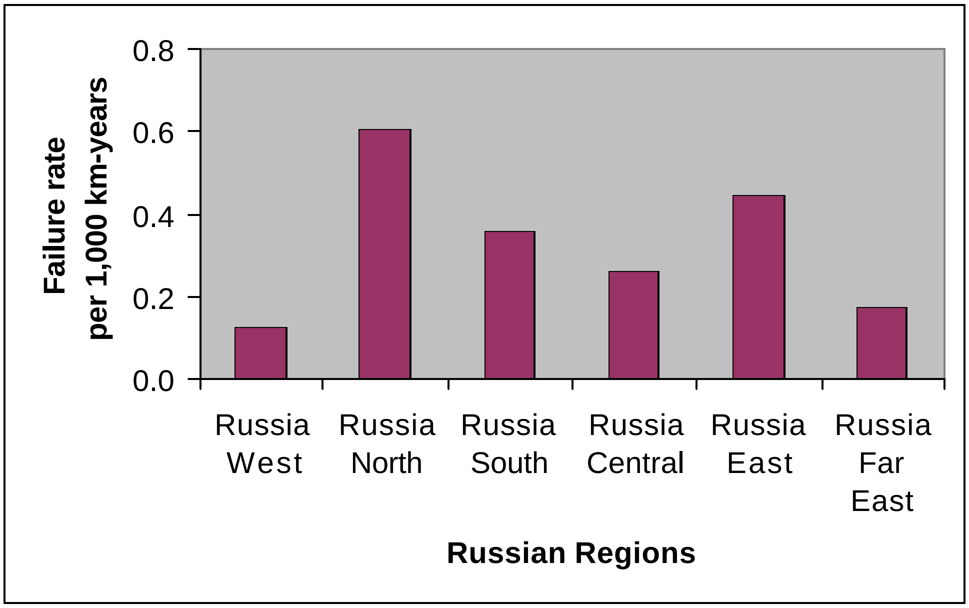
19. Some of the pipelines lie in the Arctic permafrost areas while others are located in the areas south of the tundra region. The tundra environments are particularly susceptible to physical disturbance, and effects remain visible for many years. Careless disturbance of the thin layer of vegetation covering a frozen soil can result in extensive erosion.

20. To facilitate the analysis of effect of climate on pipelines, the FSU countries were further divided into 6 geographical subregions (see Pipeline Network Maps, Appendix A, and Data on Oil Spills, Appendix B, for definitions). These subregions consist of:

- ?? *Russia North*, which lies mainly in the permafrost climatic region;
- ?? *Russia West*, comprising the countries of Estonia, Latvia, Lithuania, Belarus, Ukraine, and Maldova;
- ?? *Russia East*, and
- ?? *Russia Far East*;
- ?? *Russia South* comprising the countries Georgia, Armenia, Azerbaijan, Turkmenistan, Kazakhstan, the Kyrgyz Republic, Uzbekistan, and Tajikistan; and
- ?? *Russia Central*.

21. More than 7,000 pipeline kilometers (9 percent of total FSU pipelines) are located in the permafrost areas. Nineteen of the 113 reported incidents (17 percent of total FSU incidents) occurred in these areas, indicating a somewhat higher regional probability for oil pollution.

Figure 3. Variation of Failure Rate by Regions in Russia, 1993–96



Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997

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22. Only five of the permafrost spills (26 percent of total permafrost incidents) were reported to pollute rivers, lakes, or potable water, compared to 34 percent of total reported incidents. Eleven permafrost spills were reported to result in soil pollution (58 percent of permafrost incidents compared to 36 percent of total incidents); however, most of the (7 incidents) were reported to result in only slight soil pollution.

23. The spill data obtained does not give a descriptive or complete picture due to insufficient detail. Furthermore, the obtained information about the geographical location of the pipelines is not sufficiently detailed to permit a good assessment of the impact of specific environmental components or population on pipeline failures. However, on the basis of information available, Figure 3 above shows the failure rates in these regions. In Russia North and Russia East, which lie mainly within the tundra and permafrost climatic regions, the failure rates are higher than in the other regions. In Russia West, where the range of temperatures is not as high as in Russia North, the failure rate is lower than for any of the subregions, which shows that there is a higher frequency of oil spills in the permafrost areas.

Environmental risk assessment

24. Environmental risk is a combination of the restitution time, defined as the time required for the natural resource environment to recover from the damage, and the probability that a rupture would occur in that environment. Oil from pipeline accidents flows along the lowest terrain, which is predominantly wetland and aquatic systems. Oil spilled from a buried pipeline will at first spread by gravity below ground, but will eventually reach the surface. The speed at which this occurs depends on the porosity of the soil and the position of the water or permafrost table. The surface flow of the oil will follow natural drainage ways and

may eventually reach streams and rivers. Once oil has reached flowing water it is transported and dispersed to larger areas and has the potential to cause more extensive damage.

25. The characteristics and effects of oil spills in standing water wetlands and rivers are summarized in the Table 4 below.

Table 4. Characteristics of Oil Spills in Standing Water and Rivers

Standing water wetland	*Rivers*
Long residence time of oil	Short residence time of oil
Interior oiling and pooling	Fringe vegetation oiling
Slow recovery rate	Rapid recovery rate
Difficulty of access	Accessible
Relatively difficult to clean	Effective natural cleaning due to currents

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

26. The information about the environmental effects of reported oil spills in the FSU is limited. As shown in Table 5 below, 38 of the total 113 incidents were reported to pollute rivers, but only a few of the reports included detailed information about environmental damage. It is believed, however, that the number of environmentally harmful incidents may be underreported.

27. The number of reported incidents in FSU is comparable to Western Europe. However, it is unlikely that the many incidents about which there is no information concerning pollution of soil or water were actually incidents that had no environmental effect. About 60 percent of the incident reports in the FSU provide no information about soil pollution, whereas all reports from Western Europe assess soil pollution. Even if only the 42 incidents with information about effects on the soil are used, 24 out of the 42 incidents or about 57 percent resulted in significant pollution, compared to 36 out of 122 incidents or 30 percent in Western Europe.

Table 5. Analysis of Environmental Damage to Pipelines in FSU (1986–96)

	1986	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*Sum FSU 1986–96*	*West. Europe 1986–96*
Number of incidents	1	3	4	8	21	19	28	29	113	124
Pollution resulting										
No information				—	1	—	—	—	1	5
Soil										
Slight	—	1	—	—	1	3	6	6	17	81
Significant	—	1	—	2	5	3	6	7	24	36
No information	1	1	4	6	14	13	16	16	71	0
Water courses										
Slight				—	—	—	—	—	—	16
Significant	1	1	4	5	6	3	7	11	38	12
No information		1		3	11	16	19	12	62	0
Potable water	—	—	1	1	1	2	2	1	8	4

— = Not available.

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

28. Likewise, 38 out of 46 incidents with information about water pollution, or 82 percent, resulted in significant pollution, compared to 12 out of 32 incidents (37 percent) in Western Europe. This indicates that a majority of reported oil spills have caused severe water pollution in FSU.

REGULATORY AND MONITORING REGIMES

29. The regulatory and monitoring policies of the FSU, and the agencies responsible for implementing policies concerning oil spill contingencies and risk assessment, were compared to representative regimes of industrialized countries in Western Europe and North America, particularly Canada. Using criteria such as geographic and climatic similarities and density of population, the Canadian legal and institutional regime was chosen as a basis for comparison of Western and FSU practices. The general impression was that Russian regulatory and monitoring regimes are more fragmented, less accountable, and less able to quickly delegate responsibility to the relevant agencies when spills occur. The result is that oil spills in the FSU create more environmental damage than in similar environments in Canada, due to slow response and inappropriate containment methods. These deficiencies could be partially blamed on the centralized planning system of FSU, which results in the existence of several agencies with unclear and overlapping responsibilities.

Oil spill contingency

30. Generally, an oil spill contingency plan must include the following methods of containment:

?? **Mechanical:** This class includes all responses that rely on the use of skimmers, booms, pumps, or heavy machinery such as trucks, bulldozers, and excavators.

?? **Manual:** This involves the use of sorbents to remove the oil selectively or shovels to remove contaminated soil, gravel, and so forth. Presumably this response class is highly underreported here. It is likely that some type of manual recovery accompanies most mechanical methods.

?? **Berming:** This involves the construction of dams or berms to contain the spill at the emergency location or to prevent oil from reaching rivers or other bodies of water.

?? **In-situ burning**: This method involves ignition and burning of oil at the spill location. This must be distinguished from unintentional ignition, which occurred in about 25 percent of reported spill incidents.

?? **Bioremediation**: This involves the controlled use of bacteria to promote natural degradation of the oil.

31. In the FSU countries, the main containment method is in-situ burning. This is highly discouraged in developed countries because of the hazardous effects that fumes and emissions caused by burning could have on the environment and the surrounding population. Oil spill contingency plans for the pipeline network in FSU also lack established routines or clear policies and as a result, are inadequate or unreliable for rapid response to oil spills.

32. Some facilities using other methods beside in-situ techniques were identified in the Russian Federation, and there may be different contingency resources in other FSU countries as well. However, the systematic organization required for effective contingency planning seemed to be absent. Among the vital elements missing were the following:

?? development of appropriate contingency plans for different environments and situations;

?? logistics of plan implementation;

?? equipment and methods to be used

?? continuous training of operators in specific methodologies.

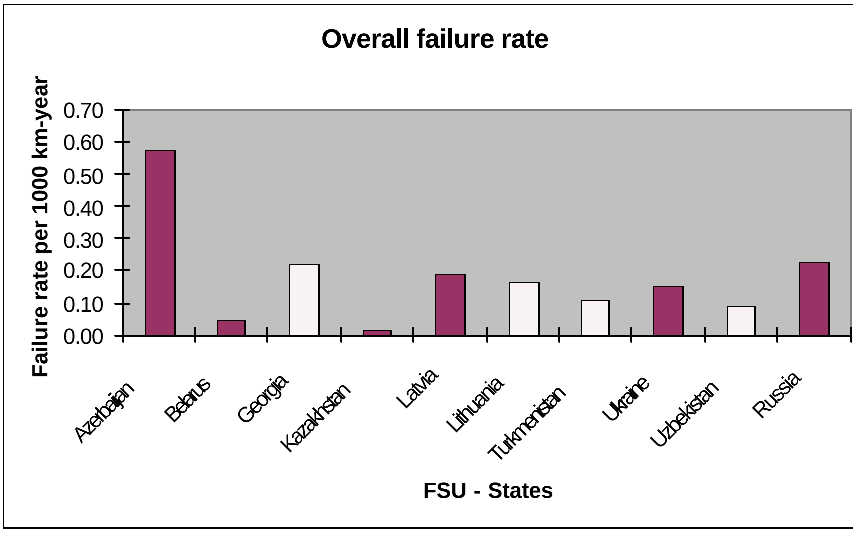
33. As a result, routines for detecting spills in FSU are failing because they are poorly applied and long-term leakage to the ground and surroundings is occurring. Furthermore, the ability or willingness to act is sometimes hindered when the effective response to spills entails financial loss due to the closure of the pipeline.

Spill risk assessment

34. A detailed analysis of pipeline accident data for the period 1990–96 was performed on a country-by-country basis in order to highlight any differences between countries or regions and to identify the main reasons for these differences.

35. Figure 4 presents the failure rate (or accident spill rate) for each of the FSU countries. Except for Russia, the data on the number of oil spills reported in other countries of the FSU is limited. No spills were reported for Georgia, Lithuania, Turkmenistan, and Uzbekistan, and the frequency rates shown in Figure 4 for these countries (the light-colored bars) are based on a statistical estimate of less than 7 failures (50 percent confidence in Poisson distribution for zero events).

Figure 4. Variation of Failure Rate by FSU States for All Oil Spills



Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

36. Table 6 presents the gross volume spillage for the FSU. The average reported amount spilled per 1,000 km-year for FSU in the years 1990 to 1996 is estimated to 371 metric tons as compared to an average in 1971–93 of 116 metric tons in Western Europe.Even if the large oil spill of 104,422 metric tons in Russia North (the Komi republic, 1994) is excluded, the average metric tons spilled per 1,000 km-year is 194, more than the average in Western Europe.

37. In Western Europe the spillage oil volume per oil volume transported averaged 4.4 parts per million from 1971 to 1993. Table 6 presents the metric tons per million transported in FSU in the years 1990–1996; the average oil volume spilled per oil volume of liquid transported was calculated to be 55 parts per million. Although it is more than likely that this figure is underestimated, the conclusion is that the amounts spilled per ton transported in FSU are higher than in Western Europe.

Table 6. Gross Volume of Spillage

Location	*Amount spilled (metric tons), 1990–96*	*No. of km-years, 1990–96*	*Million metric tons transported, 1990–96*	*Metric tons spilled per 1,000 km-year*	*Metric tons spilled per million metric tons transported (ppm)*
FSU Total	218.536	588.379	4.000	371	55

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

CONCLUSION AND RECOMMENDATIONS

38. The following are the main conclusions and recommendations from this study.

(a) Among the FSU countries, Azerbaijan, with 0.8 percent of total pipeline kilometers, has the highest pipeline failure rate for the analysis period. The failure rates in Belarus and Kazakhstan (with 3.4 and 9.8 percent of total pipeline kilometers respectively) are the lowest. The difference could be due to a variety of factors, such as:

?? differences in the ages of pipelines;

?? differences in environmental, climatic, geological, and soil conditions and their effects on pipelines and pipeline routing: ,

?? differences in construction standards;

?? differences in implementation of contingency plans; and

?? differences in reporting thresholds for oil spill events.

The above factors should be reviewed in greater detail so as to establish more succinctly the relevant parameters explaining the differences in failure rate.

(b) Except for Russia, the number of oil spills in each FSU country is small when compared to the volume of oil transported. However, this conclusion is based on the limited amount of data available.

(c) Comparing the six geographical subdivisions of Russia used in this report, Russia North and Russia East, which are located in the tundra climatic region, have higher pipeline failure rates (at 0.6 and 0.5 per 1,000km-years respectively) than Russia West, with a pipeline rupture rate of about 0.15 per 1,000 km-years. This result indicates that pipelines in the Tundra region are more susceptible to ruptures than in the other climatic regions.

(d) Failures due to third-party activities are significant in both FSU and Western Europe, thereby highlighting the need for establishing an effective regulatory and monitoring mechanism for oil pipeline operation.

(e) On the basis of the limited data set used, there are more mechanical failures and operational errors in FSU than in Western Europe. This could be due to the utilization of poor pipeline materials, poor construction standards, poor supervision, or lack of clarity of responsibilities in the legislative and regulatory framework. The higher number of spills in the FSU could also indicate that the Russian pipelines examined in this study are older than lines in Western Europe.

(f) The specific ages of the pipelines in which the ruptures occurred were not available, and hence it was not possible to clearly establish the statistical significance of this parameter as a cause of pipeline rupture. The age of pipeline would seem to be an important parameter for the failure rate. Moreover, the failure rate of pipelines usually follows a bathtub curve: at the start and the end of the lifetime, the failure rates are high, but in the middle of the lifetime the failure rates are usually low. This could be due to '"teething"' troubles for new pipelines and wear-and-tear as the pipeline gets old. This curve could explain some of the differences in failure rates between FSU states and Russia. In the countries of FSU, the pipelines are relatively new, but in Russia, most pipelines were put in operation in the 1960's and 1970's. As of the year 2000, about 73 percent of the pipelines in FSU were older than 20 years. It is recommended that the effects of the age of pipelines should be studied and correlated with the frequency of spill occurrence.

(g) The severity of spillage, measured by the amount of oil spilled, is higher in the FSU than in Western Europe. The reason could be poor contingency planning and delayed responses to spills when they occur; poor detection procedures; long distances between emergency shutdown valves; or the larger average diameter of pipelines in the FSU than in Western Europe. All these factors are relevant and should be further analyzed in the next phase of the project.

(h) The regulatory and monitoring systems of FSU systems are more fragmented than those of Canada, and as a result are considered less effective in providing quick response to oil spills. There are many organizations involved in the FSU system and accountability for responding to spills is lacking. The Canadian regulatory system is considered more suitable for regulating pipeline operations in developing countries than the FSU system, provided that the Canadian system is appropriately modified to reflect the local laws and regulations in the respective countries.

(i) With regard to strengthening the regulatory and monitoring regimes of the FSU, the following actions are recommended:

- The general fragmentation of the legal and institutional frameworks of the Russian Federation should be further reviewed. However, the authors believe that the current fragmented nature of the frameworks makes the coordination between the different federal bodies and agencies difficult, and also makes the regulatory responsibilities of the different agencies involved unclear.
- The pipeline operating procedures, standards, and norms are old and should be updated. In particular, it is recommended that standards and norms (also the industry norms) be updated in line with the new Onshore Pipelines Regulations issued by GOST, and the CSA pipeline standards.
- The FSU legal and regulatory frameworks are considered by the pipeline operators and owners to focus more on punishing offenders than on providing guidance for efficient and safe operation of the pipelines, and this creates an unwillingness by the pipeline operators to report spill occurrences. Therefore the focus of these frameworks should be changed to encourage a more preventive approach that emphasizes institutional awareness of the environmental impact of oil spills.

(j) The data gathered in this study on the causes of oil spills from pipelines show that mechanical failures and operational errors are the main causes of pipeline failures in the FSU (at 42 percent and 10 percent respectively), as compared to 26 percent and 5 percent respectively in Western Europe. Attempts should be made to reduce the effects of these factors through better monitoring of pipeline operations.

Presentation of Report

39. The overall framework and methodology for the study is described in Chapter 2. The database used in this study for the pipeline network and oil spills is discussed in

Chapter 3. Chapter 4 discusses the legal, regulatory and monitoring systems of the FSU and Western countries. Comparison with the Canadian monitoring and regulatory systems highlights the shortcomings of the FSU system. Chapter 5 discusses oil spill contingency planning and resources for responding to pipeline incidents. Environmental risks and oil spill risk assessments and analyses are given in Chapter 6 General conclusions and recommendations of the study are given in Chapter 7. Several references that were used for this study are provided in the Bibliography. Attached to the report are seven Appendices (A-G).

1

Introduction

1.2 Major pipelines cross the world transporting large quantities of crude oil, natural gas, and petroleum products. These pipelines play an important role in modern societies and are crucial in providing needed fuels for sustaining vital functions such as power generation, heating supply, and transportation. Pipelines may be found either offshore (sub-sea) or onshore (buried, trenched, or on the surface). In light of the hazardous properties of the products being transmitted through these pipelines, a ruptured pipeline has the potential to do serious environmental damage. As new pipeline networks are being constructed and more heavily utilized, especially in developing countries, there is increased potential for significant spills. This problem is further compounded by the fact that many developing countries have not established proper guidelines and standards for the design, construction, and operation of major oil pipelines. Moreover, some of these countries have not established adequate procedures and regulations for addressing environmental concerns related to spills, or lack the institutional capacity to implement the procedures. One reason for these shortcomings is the lack of funds to implement proper maintenance and operation of the pipelines and to maintain appropriate contingency plans and facilities to combat oil spills as in developed countries of Western Europe and North America (such as Canada).

1.3 In order to reduce the frequency and consequences of oil spills, it is of great importance that appropriate standards, guidelines, regulations, risk management procedures, and so forth are developed based on existing regimes and experience in North America and Western Europe. In addition, adequate funds must be allocated to monitor compliance with these standards and procedures.

1.4 In November 1997 the World Bank contracted Det Norske Veritas (DNV), a consulting firm from Norway, to undertake a desk study to evaluate the procedures for pipeline maintenance and contingency plans for addressing oil spills in Russia and the former Soviet Union states (FSU). The scope of the study included collection of relevant data, data analysis, and assessment of the risk of pipeline spills in these countries.

1.5 DNV performed the study during the period of December 1997 to October 1998, and the results of the analysis and recommendations are documented in this report.

OBJECTIVES

1.6 According to the Terms of Reference (World Bank, 1997), the overall objective of the study, was to develop a knowledge base on oil pipeline spills in Russia and the republics of the Former Soviet Union. This knowledge would be used to generate a greater awareness and promote education on the factors that influence pipeline ruptures and oil spill damages. The data would also form a basis for developing preventive and mitigation measures to reduce and minimize the impact of future spills. More specifically, the objectives of the study have been categorized into the following five different areas of activities:

?? Study the historical oil pipeline spills.

?? Assess oil pipeline rupture risk and recommend measures to reduce oil spill probability and impact severity.

?? Identify best practices in developed countries and recommend ways of translating these to areas having inadequate arrangements for combating oil spills and mitigation of their effects.

?? Promote establishment of regulatory and monitoring systems.

?? Promote the development of incentive systems to encourage the oil industry to minimize environmental degradation arising from oil pipeline spills (in particular).

SCOPE OF WORK

1.7 In order to fulfil the study objectives a number of work tasks were identified, comprising:

?? collection of data on pipeline network of FSU;

?? analysis and risk assessment of the pipeline network data;

?? review of the legal and regulating regimes of FSU and comparison of these regimes with those of Canada; and

?? recommendations for strengthening the regulatory and monitoring systems in FSU.

These tasks are outlined in more detail in the following sections.

Data collection

1.8 Data was collected from known periodicals and other literature, as well as the databases of several companies, government institutions, and agencies that are responsible in the FSU countries for operating the pipelines. The data collected included the following types:

?? **Pipeline network data** of the major crude oil and product trunk transportation pipelines, including feeder lines and local gathering systems (where applicable) in the countries of Former Soviet Union. Flowlines and other piping and in-field pipelines associated with the operation of oil fields, refineries, and stock tank areas were not included.

?? **Oil spill data** during the period 1986–96 from the pipelines. Types of data collected included: date of event, site specification (that is, pipeline identification and geographical location), spill quantity and duration, causes and consequences, cleanup and restoration, and so forth. This data allows the determination of spill frequencies (number **cleanup** of spills per pipeline-kilometer) and identification, when possible, of ““high-risk” areas and trends (over time).

?? **Geographic and environmental data** to identify important environmental factors, as well as populations, habitats, or other environmental features of each country along the pipelines that are vulnerable to oil spills. This data category also includes qualitative evaluations of the effect of climatic conditions on the rupture rates of pipelines.

?? **Legal and regulatory data** to evaluate if the factors that have been established as major causes of pipeline ruptures under the internationally accepted CONCAWE nomenclature are covered comprehensively by the legislative and regulatory frameworks in the countries. Under the CONCAWE categorization, the main causes of pipeline ruptures are: mechanical failures; corrosion; operational errors; third-party activities and natural hazards.

?? **Oil spill contingency** plan data including existing contingency plans, type of cleanup equipment, capacities, and so forth in the given countries.

Data analysis and risk assessment

1.9 Based on the data collected, detailed analyses and assessments were carried out to do the following:

?? Document any trends (over time) and differences (between countries/regions). In addition, advise on the reasons for the latter.

?? Investigate and quantify possible correlation between spill frequency, extent, and severity with relevant factors causing spills (such as lack of maintenance, regulations and standards, and operating practices).

?? Identify pipelines with high rupture risk, explain the nature and extent of the problems, and recommend action plans for mitigation.

?? Document lessons learnt and best practices from countries outside Russia and the FSU and explain how these can be applied in the areas of concern.

Recommendations for strengthening the regulatory and monitoring systems

1.10 The current regulatory and monitoring practices in Western Europe and North America were compared with those of Russia and the FSU to identify the differences and weaknesses of the systems in the FSU countries and to recommended ways for overcoming these weaknesses. The regimes in Canada were used as basis for comparison with those of Russia and the countries of the FSU.

LIMITATIONS AND ASSUMPTIONS

1.11 The study has only used oil spill data for main crude oil pipelines in Russia and the countries of the Former Soviet Union during the period 1986–96. This data is very limited in scope and in some cases the quality is poor. However, according to available sources, crude oil pipelines of different diameters and age are found in the following ten countries of the FSU:

?? Baltic States: **Latvia**, **Lithuania**

?? **Belarus**

?? Central Asia: **Kazakhstan**, **Turkmenistan**, **Uzbekistan**

?? **Russia**

?? Transcaucasia: **Azerbaijan**, **Georgia**

?? **Ukraine**

2

Database for Oil Spill Analysis in FSU

2.1 A database was developed to facilitate the analysis of oil spill frequencies and to identify the factors responsible for pipeline ruptures. The content of the database is discussed below.

PIPELINE NETWORK DATA

2.2 Most of the pipeline data was accessed from a digital map of main oil pipelines on a CD-ROM. The CD-ROM was prepared by the Scientific Technical Centre of Means, Communications and Transportation (NTT's "KOMTRANS"), Moscow, Russia. The data included location of pipelines, diameter in inches, "and length in kilometers. The diameters of nearly all the pipelines obtained from this source were available. In cases where the pipeline diameters were not given, they were estimated by applying the same diameter as that of the neighboring, parallel, or connecting pipeline(s). The data have been categorized on a country-by-country basis and are summarized in Table 2.1 below. The locations of the pipelines and the approximate geographic position of the oil spills are shown in the map in Appendix A.

Characteristics of the oil pipeline network in the FSU

2.3 There were approximately 84,000 kilometers of pipeline in the FSU as of 1998. About 90 percent of this pipeline has a diameter of >20" inches. About 64,000 pipeline kilometers, or 76 percent of the total, are located in Russia. The distribution of these pipelines in the regions of Russia is shown in Table 2.2.

2.4 Unlike other countries, the main pipelines in Russia are combined into unified systems that transport natural gas, oil, and petroleum fuels to both domestic and international end users. Natural gas is transported exclusively by Gazprom (RAO) the Russian oil and gas company; oil is transported by AK Transneft, the national pipeline operator; and refined petroleum fuels are taken care of by AK Transnefteprodukt, the state-owned refined products pipeline company. The aim of such centralized organization and pipeline networks is to provide for maximum capacity utilization, flexibility, efficient and timely flow control, and reliable operation. However, as discussed in articles from the Russian natural-resource periodicals "Neft I Kapital," "Gazovaya Promyshlennost," and "Neftegazovaya Vertikal" (DNV, 1997), insufficient care and attention is given to reliability and safety during the design, construction, and operation of these pipelines. Pipelines, despite their apparently simple structure, are substantially different from other transportation infrastructures. They are often subjected to complex impact forces and varied loads that could create an unbalanced stressed or strained state, leading to early ruptures. This is significant for buried pipelines.

Table 2.1 Number of Pipeline Kilometers by Diameter and FSU State

Diameter (inches)	*Azerbaijan*	*Belarus*	*Georgia*	*Kazakhstan*	*Latvia*	*Lithuania*	*Russia, all regions*	*Turkmenistan*	*Ukraine*	*Uzbekistan*	*Total FSU*
6	—	—	22		—	—	—	—	—	14	36
9	—	—	—	48	—	—	155	—	28	165	396
10	—	—	—		—	—	126	—	—	169	295
11	136	—	—	148	—	—	496	—	—	52	832
12	—	—	—		—	—	52	—	—	—	52
13	24	—	—	60	—	—	1,156	361	—	—	1,601
15	—	—	—	356	—	—	1,731	226	197	—	2,510
16	—	—	—	274	—	—	—	—	—	—	274
17	—	—	—	—	—	—	1,112	—	—	—	1,112
20	—	—	—	—	—	—	461	—	—	—	461
21	183	95	423	1,483	—	—	12,852	132	742	—	15,910
25	—	598	—	398	—	—	—	160	—	670	1,826
28	403	446	—	958	753	606	16,099	25	2,874	—	22,164
32	—	1,455	—	1,929	—	—	7,058	—	—	—	10,442
40	—	335	—	2,597	—	—	10,283	—	456	—	13,671
44	—	—	—	—	—	—	81	—	81	—	162
48	—	—	—	—	—	—	12,150	—	161	—	12,311
Total	746	2,929	445	8,251	753	606	63,812	904	4,539	1,070	84,055

—= Not available.

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Table 2.2 Number of Pipeline Kilometers in Russia, by Region and Diameter

	Region						
Diameter (inches)	*North*	*South*	*West*	*East*	*Far East*	*Central*	*Russia, total*
6	—	—	—	—	—	—	—
9	—	115	—	—	—	40	155
10	—	—	—	—	—	126	126
11	110	120	—	—		266	496
12	—	—	—	—	—	52	52
13	41	208		200	112	595	1,156
15	—	174	—	—	—	1,557	1,731
16	—	—	—	—	—	—	—
17	—	11		327	467	307	1,112
20	—	—	—	461	—	—	461
21	159	1,669	632	3,663	845	5,884	12,852
25	—	—	—	—	—	—	—
28	1,065	2,074	3,620	7,140	—	2,200	16,099
32	2,326	1,179	840	1,120	—	1,593	7,058
40	—	1,978	1,905	394	—	2,479	10,283
44	—	81	—	—	—	—	81
48	—	743	495	7,336	—	3,176	12,150
Total	3,701	8,351	7,893	24,160	1,424	18,275	63,812

— = Not available.
Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Age and reliability of pipelines in FSU

2.6 The specific age of some of the pipelines is not known, and it was not possible to make an objective correlation between the age of pipelines and their rate of rupture. However, a large number of the oil pipelines in Russia was put into operation in the 1960's and 1970's (see Table below). As of the year 2000 pipelines older than 20 years constituted 73 percent of all pipelines over 30 years old, or 41 percent of the total network length.

Table 2.3. Age of Russian Main Oil Pipelines

	Year	
	1995	*2000*
Age, years	%	%
< 20	46	27
20—30	29	32
> 30	25	41

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

2.7 Based on articles given in Neft i Kapital, Gazovaya Promyshlennost, and Neftegazovaya Vertikal (DNV, 1997), in which the reliability of pipelines with regard to age was studied over a three-year period, a correlation is possible between the ageing of pipelines and their failure (rupture) rate. Similar experiences have been noticed with pipelines in Western Europe (CONCAWE 1998). In FSU it was observed that over 30 percent of failures occur with pipelines with more than 20 years of operation. Furthermore, that there is an increase in operational hazards with older pipelines, which could be due to the ageing effect of the steel used in pipeline manufacturing. Ageing of steel leads to undesirable changes in its properties, including a decrease in plasticity.

2.8 The ageing of the pipe metal in itself is no reason to stop using the pipeline, although operation parameters such as permissible pressure and temperature ranges may have to be adjusted accordingly. Furthermore, ageing of oil pipelines does not inevitably result in more pipeline failures as can be seen from Western Europe. Over the last 25 years the proportion of very old pipelines (> 50 years) in Western Europe has increased considerably while the proportion of young pipelines (20 years has) dropped to less than 5 percent of the total pipeline length. During the same period the pipeline failure rate has dropped from 1.2 failures per 1,000 km-years to about 0.4 failures per 1,000 km-years (CONCAWE).

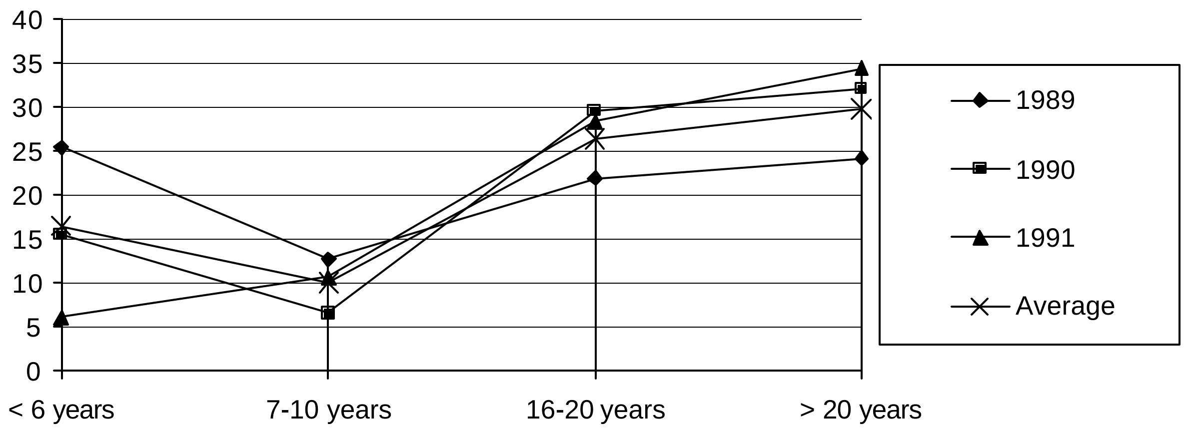
2.9 However, pipelines should be regularly evaluated in order to estimate their remaining lifetime, and the procedure should test such properties as cracking resistance, strain hardening, microhardness, and so forth. According to the Gas and Oil Pipeline Standards (GOST) of Russia, the standard lifetime of pipelines is 33 years. Figure 2.1 below shows the percentage change in the number of accidents during a pipeline's service life. As shown in the figure, during 1992–96 the accident frequency for the early period of utilization of the pipelines (< 6 years) dropped from 25 percent to 5.9 percent. At the same time the accident frequency for pipelines 20 years old or older increased to 38 percent.

2.10 Generally, the failure rate of pipelines with regard to age follows a bathtub curve. At the start and at the end of their lifespans, pipeline failure rates are high, but lower in the middle lifespan (Figure 2.1). This could be due to "teething " problems for new pipelines and to wear-and-tear as pipelines age.

Corrosion effect on pipeline ruptures

2.11 Application (or nonapplication) of anticorrosion materials to pipelines, both internally and externally, was an important factor with regard to the reliability of the Russian pipelines . Most large-diameter gas and oil pipelines have special anticorrosion insulation, made of polymeric tape and applied in accordance with field characteristics (including the environment). For more detail on corrosion effects on pipelines, see Appendix F. In Russia, it was observed that the absence of factory-made insulation materials such as polymeric tapes accounted for a major part of corrosion-related failures. When constructing new main pipelines, priority must be given to the use of factory insulated pipes, as was the case in the first gas pipeline of the Yamal-Europe system. (The Yamal-Europe transit gas pipeline with a total length of approximately 4,000 kilometers will connect Wester Europe with rich natural gas deposits on the Yamal penninsula.) This pipeline has been able to withstand major corrosion over time.

Figure 2.1 Accidents on trunk oil and gas pipelines vs time in service (%)



Source: V.Dinkov (Gasprom), O.Ivantsov (Rosneftegasstroy), 1997 Pipeline Oil Spill

Prevention and Remediation in FSU, DNV, 1997.

2.12 More than 50 percent of corrosion incidents in Western Europe have occurred in pipelines laid on road crossings, anchor points, sleeves, etc., riverbed areas and defective riverbank support (CONCAWE, 1998 report no.). Since it is impossible to use internal corrosion diagnostic equipment for buried or underground pipelines, corrosion effects in these types of pipelines are diagnosed by means of sonar detection, underwater video monitoring, electromagnetic siphon location detection, coordinate spacing, and so forth. Studies of 566 underwater transfer lines showed that 120 lines needed repairs due to corrosion.

2.13 In Russia, the lack of adequate financing has made "Transneft," the national pipeline operator, switch over to selective repair and rebuilding strategies. The works (including pipe replacements) are carried out on potentially hazardous areas of pipe that were detected in the process of internal pipe diagnostics. A special "Technical Diagnostics Center" was established.

2.14. During its 5 years of operation (from 1992 to 1996) the Center performed profile tests (68 percent) and ultrasonic diagnostics (18 percent) of main oil pipelines. By 1997, about 2,000 kilometers of Transneft-subsidiary Sibnefteprovod's main oil pipelines have been tested with internal pipe flaw detectors of the Ultrascan and Caliper types, revealing about 6,000 defects.

2.15 To ensure that special attention is paid to the importance of reliability and safety of pipeline systems, in August 1996 the former Chairman of the Russian government Mr. Victor Chernomyrdin and the former Ukrainian Prime Minister Mr. P. Lazarenko initiated the development of an updated version of the interstate scientific and engineering program "Highly reliable pipeline transport." As a result, existing Russian design and construction regulations are being reviewed under the above program for main supply and production pipelines that have not been renovated for 15–18 years. The goal is to update regulatory requirements with modern know-how and technology and to align the Russian regulations with those of European countries, the United States, and Canada. Other FSU states have expressed their intention to participate in the program. The program has a comprehensive approach to all reliability and safety aspects of pipeline transport facilities. This may lead to a significant improvement in the reliability of Russian pipelines.

Climatic impact on pipeline ruptures

2.16 FSU countries occupy a geographical area that spans several different climatic zones, and hence these pipelines are likely to be subjected to the effect of climatic changes. Most of the oil and gas resources of Russia are located in the northern and subartic regions of west and east Siberia (the republics of Komi and Sakha and the island of Sakhalin). These permafrost areas have very rough climatic conditions.

2.17 Pipelines crossing west Siberia and the Republic of Sakha experience loss of their longitudinal stability caused by pipeline surfacing (floating), arching, and corrugation. This happens because pipes are being laid in grounds with low bearing capacity, such as water-saturated and marshy grounds. Areas with permafrost are also problematic because, when melted, permafrost dramatically loses its carrying capacity. The loss of longitudinal stability is also caused by the temperature differences during the pipeline laying process, the summertime operation of the gas pipelines, and the oil heating procedure required for transportation of viscous paraffin-based oils. As a rule, large temperature drops lead to huge axial forces.

2.18 In recent years longitudinal stability of the gas pipelines was achieved by reburying and in some cases by relaying. As for oil pipelines, the solution was to replace underground pipelines running through soil of low bearing capacity with surface pipelines. Maintenance of the gas pipelines laid in permafrost required a more radical solution, including the forced lowering of the temperature of the transported gas. However, lowering the gas temperature in permafrost areas may lead to restoration of permafrost followed by restraining of the pipes, in addition to swelling where soils with different absolute swelling factors contacted. A detailed description of the climatic conditions in the FSU countries is given in Appendix G.

OIL SPILL DATA

2.19 Several relevant, publicly available sources were consulted to obtain information on crude oil spills from pipelines in the FSU. This data search identified 113 crude oil spill accidents in the period 1986–96 (both years included). Summary descriptions of each accident are given in Appendix B, and the relevant statistics are discussed in the following paragraphs. The map in Appendix A shows the approximate geographic location of the accidents.

Data sources

2.20 The main sources of information for oil spills cited in this study were the following:

Database of the Oil Spill Intelligence Report (OSIR), United States.
Lloyd's Casualty Report (LCR), London, United Kingdom.
Hazardous Cargo Bulletin (HCB), United States.
Oil and Gas Journal (OGJ), United States.
Major Hazard Incident Data Service Database (MHIDAS); Health and Safety Executive (owner), AEA Technology (operator), United Kingdom.
Institution of Chemical Engineers Accident Database (IChemE), United Kingdom.
Ministry of Emergency Situations and Mitigation of the Results of Catastrophes (MChS), Moscow, Russia. Note: MChS covers oil spill accidents in the Russian Federation after 1993. (The name of the ministry is translated from Russian. The short form in this paper is Ministry of Emergencies).

2.21 It is important to emphasize that no detailed investigation of single accidents were performed in this study to obtain further information beyond what is directly reported in the sources listed above. However, in addition to the data sources listed above, other sources considered relevant and that were consulted include: TNO's (Holland) database FACTS and JRC's (Italy) database CHEMAX, and from the following ministries in Russia:

?? Ministry of Economy

?? Ministry of Fuel

?? Ministry of Transport

?? Ministry of Emergencies

??

2.22 In FSU, *feeder lines* are typically owned by the *operator companies* ("Lukoils"), while *main crude lines* are owned and operated by Transneft. Thus the best source of crude oil pipeline data is Transneft. However, this company guards its pipeline data and considers them proprietary; access to the data is not possible without developing a long-term, elaborate, and strategic relationship with the company. The data on spills between 1993 and 1996, representing a wide and representative set of *major* spills in Russia, were obtained from the Ministry of Emergencies. It is a national requirement that the Ministry of Emergencies is notified of all major spills posing a hazard to human health and the environment. The 113 recorded accidents represent only a fraction of the total number of spills that really have occurred, as independent sources have indicated that some pipelines had experienced several hundred smaller spills in one year due to their bad conditions (some of which were not reported to the ministry). Nevertheless, the 113 spills analyzed in this study are representative of the *major* spills with the greatest impact on the environment or economy, and for which cleanupand recovery works have been monitored, carried out, or financed by foreign countries or organizations.

Oil Spill Statistics

2.23 The relevant data on each of the spills are summarized in Tables 10–13 below. The causes of spills were analyzed in accordance with the internationally accepted CONCAWE, 1997, nomenclature, which consists of the following categories shown below.

Mechanical failure:
- ?? Construction
- ?? Material
- ?? Structural

Corrosion:
- ?? Internal
- ?? External

Operational failure:
- ?? System
- ?? Human

Third-party activity:
- ?? Accidental
- ?? Malicious (sabotage)
- ?? Incidental
- ?? Act of war

Natural hazard:
- ?? Subsidence
- ?? Flooding
- ?? Other

2.24 Other factors such as climatic effects, age of the pipeline, and characteristics of the environment are also important and their effect on the pipelines in FSU have been quantitatively considered and described in this study

Table 2.4 Number of Oil Spill Accidents by Location (State/Region) and Year of Occurrence, FSU 1986–96

	Year of occurrence								
Location	*1986*	*1990*	*1991*	*1992*	*1993 **	*1994*	*1995*	*1996*	*Total by location*
Azerbaijan	—	—	1	2	—	—	—	—	3
Belarus	—	—	—	—	—	—	—	1	1
Kaza khstan	—	—	—	—	—	—	—	1	1
Latvia	1	—	—	—	—	—	1	—	2
Russia, East	—	1	—	—	11	10	16	6	44
Russia, Far East	—	—	1	—	—	—	1	—	2
Russia, North	—	—	—	2	—	1	5	3	11
Russia, South	—	—	1	1	3	1	1	8	15
Russia, West	—	—	—	—	—	2	1	2	5
Russia, Central	—	2	1	2	4	5	3	7	24
Ukraine	—	—	—	1	3	—	—	1	5
Total by year	1	3	4	8	21	19	28	29	113

— = Not available.
* Data source on Russian spills introduced (covering the period 1993–96)
Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Table 2.5 Number of Oil Spill Accidents by Location (State/Region) and Cause of Spill, FSU 1986–96

Location	*Cause of spill*						
	Mecha-nical failure	*Corrosion*	*Operational error*	*Third-party activity*	*Natural hazard*	*Unknown*	*Total by location*
Azerbaijan	1	—	—	1	—	1	3
Belarus	—	—	—	—	—	1	1
Kazakhstan	—	—	—	—	—	1	1
Latvia	1	—	—	1	—	—	2
Russia East	8	7	2	9	—	18	44
Russia, Far East	1	—	—	—	1	—	2
Russia, North	5	2	—	1	—	3	11
Russia, South	4	2	2	3	1	3	15
Russia, West	1	—	—	—	1	3	5
Russia, Central	7	2	3	2	—	10	24
Ukraine	3	—	—	—	1	1	5
Total by cause	31	13	7	17	4	41	113

— = Not available.
Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Table 2.6 Number of Oil Spill Accidents by Location (State/Region) and Diameter Class, FSU 1986–96

Location	*Diameter class (inches)*					
	8–14	*15–22*	*24–32*	*> 32*	*Unknown*	*Total by location*
Azerbaijan	—	—	—	—	3	3
Belarus	—	—	1	—	—	1
Kazakhstan	—	—	1	—	—	1
Latvia	—	—	2	—	—	2
Russia,East	—	17	15	11	1	44
Russia, Far East	—	1	—	—	1	2
Russia,North	—	1	10	—	—	11
Russia,South	2	4	6	1	2	15
Russia,West	—	3	1	1	—	5
Russia, Central	6	8	4	5	1	24
Ukraine	—	—	4	1	—	5
Total by class	8	34	44	19	8	113

— = Not available.
Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Table 2.7 Number of Oil Spill Accidents by Location (State/Region) and Spill Class, FSU 1986–96.

	Spill class (metric tons)					
Location	*0–100*	*100–1,000*	*1,000–10,000*	*> 10,000*	*Unknown*	*Total by location*
Azerbaijan	2	—	—	—	1	3
Belarus	—	1	—	—	—	1
Kazakhstan	—	—	—	—	1	1
Latvia	1	1	—	—	—	2
Russia,East	10	4	7	3	20	44
Russia, Far East	—	1	1	—	—	2
Russia,North	4	3	1	1	2	11
Russia,South	4	4	1	—	6	15
Russia,West	—	1	1	—	3	5
Russia, Central	7	5	5	—	7	24
Ukraine	1	3	—	—	1	5
Total by class	29	23	16	4	41	113

— = Not available.
Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

3

Legal, Regulatory and Monitoring Regimes in FSU

INTRODUCTION

3.1 This section gives an account of the data gathered on regulatory and monitoring regimes of the FSU, with regard to safety and pollution aspects from oil pipelines. The section also reviews, as far as possible, the comprehensiveness of the legal and regulatory regimes in addressing the important aspects of oil pipeline safety and environment, such as mechanical failures, operational, corrosion, natural hazards, and third-party activities. (These are the main causes of oil spills from oil pipelines, as defined by CONCAWE nomenclature.) Finally, the legal and regulatory systems of FSU are compared with those of the Western developed countries—particularly Canada. The Canadian system was chosen for comparison because the similarities with the FSU in climactic variation and density of population.

THE REGULATORY AND MONITORING REGIMES OF THE FSU

Introduction

3.2 Oil pipelines exist in all the states of the former Soviet Union (FSU). During the Soviet period, the pipeline regulatory and monitoring regimes were basically uniform throughout the country. In each state a Gosgortekhnadzor ("Federal Mining and Industrial Supervision of Russia") was the primary agency designated to control pipeline quality, and a State Ecology Committee was the primary agency responsible for protection of the environment. The agencies were coordinated from Moscow (DNV 1998).

3.3 After the breakup of the Soviet Union, the basic structures in each state remained largely unchanged, and a Gosgortekhnadzor and an Ecology Committee typically still exist in each state and perform the same functions (DNV, 1998). Due to the system uniformity throughout the FSU, Russian regulatory and monitoring regimes reflect to a large extent the situation in the other countries of the FSU.

3.4 It was not possible in this study to present a clear picture of the regulatory and monitoring framework. One important reason is that the structures are not entirely clear, and several federal bodies have partly overlapping legal and regulatory responsibilities. Furthermore, the frameworks are changing; all states of the FSU have joined an interstate scientific and engineering program, initiated in 1996, called the "highly reliable pipeline transport" program (section 3.1). This program is aimed at bringing the regulatory requirements up to the level of modern know-how and technology in Europe, the United States, and Canada (DNV 1997). The program is therefore expected to lead to regulatory changes in all the countries of FSU covered in this study.

General Data on the Legal Framework Governing Oil Pipelines in the Russian Federation

3.5 In order to understand the Russian legal framework on oil pipelines, it is necessary to gain an overview of the pipeline system.

3.6 The Russian crude oil pipeline system is organized into two groups:

- *Local pipeline systems*, which are used to transport crude oil from the wells through processing and storage facilities to trunk pipelines. Normally local pipeline systems belong to the oil and gas production unit (NGDU) of the local operator. Local operators are generally oil companies that date back to the former Soviet Ministry of Oil Industry.
- *Trunk pipeline systems,* most of which are operated by Transneft. Transneft is a state-controlled company running trunk oil pipelines throughout the Russian Federation. However, some trunk pipelines belong to local operators. The Sakhalin-Komsomolsk line, which is controlled by Sakhalinmomeftegas (a company drilling in Russia's Far East on Sakhalin Island), is a typical example.

3.7 The total length of the pipelines operated currently by Transneft (up to 48 inches in diameter) is about 48,000 kilometers (or 57 percent) of the total length of the local pipeline system in FSU (DNV, 1998).

3.8 As the year 2000, 73 percent of oil pipelines in the FSU were more than 20 years old and 41 percent were more than 30 years old. The estimated lifespan for pipelines was set at 33 years according to the GOST Standard (Russian standard for oil and gas pipelines) (DNV, 1997). More than 30% of the main pipeline failures have occurred on the pipelines that have been in operation for over 20 years (DNV, 1998). However, the average reliability of the local systems is considerably lower than the reliability of the Transneft system. As in most countries, the federal legal framework dealing with oil pipelines consists of several levels. The main levels are as follows (DNV, 1998).

- the constitution, providing guiding principles for the laws and for the society in general;
- the federal laws, regulating more or less comprehensive areas; and
- various instructions and regulations, as well as federal standards and norms adopted by the involved authorities, regulating details of design, construction, and operation of pipelines

3.9 In addition to the federal legal framework, which is mandatory, industry standards and norms also play a role, which today is mainly for guidance and not mandatory as before when industry standards represented the standards for each Ministry (DNV, 1998a).

SAFETY ASPECTS OF OIL PIPELINES IN THE RUSSIAN FEDERATION

Legal Framework

3.10 The main law regulating the safety aspects of oil pipelines is the 1997 "Law on the Industrial Safety of Hazardous Production Facilities." The law aims to prevent incidents and ensure that organizations operating hazardous production facilities, including oil and gas field facilities and oil pipelines, are able to respond adequately to emergencies. For this purpose, the law includes a series of measures for the prevention of oil spills, such as the following (DNV, 1998).

- ?? licensing of design, construction, operation, maintenance, and decommissioning of pipelines;
- ?? licensing and certification of equipment;
- ?? requirements for design, construction, acceptance, and operation of facilities;
- ?? emergency response;
- ?? investigation of emergencies;
- ?? monitoring of compliance with relevant requirements (supervision);
- ?? requirement for the involved industry to issue a declaration of industrial safety and insure for damage liability.

3.11 The requirements of the law are of a general nature, and do not include specific requirements intended to address the main causes of oil spills such as mechanical failures, operational, corrosion, natural hazards, and third-party activities (DNV, 1998). However, the above list indicates same specific guidelines are covered by general requirements.

3.12 Other fundamental laws relevant to this study—and particularly to the safety aspects of oil pipelines—are the federal laws “On Safety” (1992) and “On Environmental Safety” (1995) (DNV,1998).

3.13 In addition to these fundamental laws, there are laws on particular issues that are relevant to oil pipelines, such as the law “On the Protection of the Public and Territories from Natural and Technology-Induced Emergencies”,(1994) (DNV, 1998).

3.14 On the level below these laws are a series of instructions and regulations with more detailed regulation of many activities, including pipeline activities. Most of the instructions have apparently been adopted by Gosgortekhnadzor. Several of the instructions are from the Soviet era and thus are generally older than the law itself (DNV, 1998).

3.15 For this study it was not possible to obtain detailed information on the contents of the instructions and regulations, and hence it was not possible to assess to what extent they include requirements intended to address the major causes of oil spills from pipelines. Nevertheless it could be inferred that these regulations are fairly general, since more detailed requirements are included in different norms and standards. As stated in Appendix D, the “Oil and Gas Industry Safety Regulations” and the “Main Pipeline Security Measures” provide the main guidance with regard to certification of products and materials used for pipelines and procedures for design of equipment to limit the occurrence of mechanical failures.

3.16 Furthermore, there are detailed federal (former Soviet) standards and norms for pipelines, which have been adopted by the State Standards Committee (Gosstandard) and the Soviet-era State Construction Committee of Russia (Gosstroi), and are as such mandatory. The different standards and norms are listed in Appendix D, and cover the following areas: (DNV, 1998).

- ?? design;
- ?? construction of main pipelines;
- ?? execution and acceptance of work on main pipelines;
- ?? requirements for main pipelines of steel; and
- ?? general corrosion proofing.

3.17 Apparently, federal standards cover mostly the main pipelines, not the feeder pipelines. In addition, all the standards and norms listed in Appendix D date back to 1983–86 (DNV, 1998, and appear to be outdated (DNV, 1998). The design requirements do not seem to cover evaluation and analysis of operational hazards (DNV, 1997). Many of the requirements that apply for the main pipelines do not apply to the feeder pipelines, such as reporting procedures.

3.18 In addition to the federal standards, there are industry standards or norms that also contain detailed regulations on oil pipelines. The standards have been adopted by the Soviet-era State Construction Committee of Russia and approved by the Ministry of Fuel and Energy of the Russian Federation. The concept of industry standards is somewhat controversial, but today they appear to be mostly voluntary. During the Soviet era, however, they were state standards for particular ministries, and thus mandatory for the state-owned industry. Apparently, the industry standards or norms are inadequate and outdated (DNV, 1998a).

Institutional Framework

3.19 The main responsibility for the safety of oil pipelines lies with the organization that operates the pipelines. This is clearly stated in the main federal legal instrument that governs the area of safety of oil pipelines in Russia—the 1997 "Law on the Industrial Safety of Hazardous Production Facilities." This law requires organizations that operate hazardous production facilities, including oil and gas field facilities and oil pipelines, be prepared to identify and eliminate the consequences of emergencies, if they occur. This is also in line with the constitution (1993), where it is stated that "owners possess, use and dispose of land and other natural resources freely, unless it harms the environment and infringes on the rights and legitimate interest of other persons" (Art. 36.2) (DNV, 1998). Still, since the state control (and ownership) is dominant in several respects (e.g. trunk pipelines), the constitutional warning against infringement does not necessarily entail significant changes in responsibilities from the days when everything was owned by the state.

3.20 The federal responsibility for ensuring that the safety aspects of oil pipelines are taken care of is divided between several government bodies. The main agency is the state Gosgortekhnadzor. By and large, its authority appears to be based on the above-mentioned law "On the Industrial Safety of Hazardous Production Facilities."

3.21 Gosgortekhnadzor is responsible for the following (DNV, 1998).

?? licensing of design, construction, operation, renovation, and decommissioning of oil and gas pipelines;

?? the licensing and certification of the technical devices used at hazardous production facilities;

?? monitoring of compliance with industrial safety requeriments for production and expert examination

?? federal industrial safety supervision.

3.22 However, it appears that the responsibility for the issuance of general requirements for the design, construction, approval, and operation of a hazardous production facility does not lie with the Gosgortekhnadzor, but with Gosstandard. Gosstandard also appears based on the incomplete information available for this study, to be the responsible body for the technical investigation of the causes of an emergency.

3.23 The Russian Federation Ministry of Internal Affairs (the Police) and the Russian Federation Ministry of Civil Defense and Elimination of Emergencies appear to collaborate on the investigation of serious accidents. In addition, the Security Council of the Russian Federation can establish—in accordance with the Industrial Safety law mentioned above—permanent and temporary interdepartmental commissions on a functional or regional basis, for the prevention of emergencies and the mitigation of their consequences (DNV, 1998).

ENVIRONMENTAL ASPECTS OF OIL PIPELINES IN THE RUSSIAN FEDERATION

Legal framework

3.24 There are several laws regulating environmental aspects of oil pipelines in the Russian Federation. Some of the laws are comprehensive, whereas others regulate particular areas. One of the most comprehensive laws is the "Law on Environmental Protection" (1991). The law establishes legal liability for environmental offences such as oil spills. According to the law offenders are obliged to give full compensation for the damage inflicted on the environment and on human health. The principle of the law is in line with the Constitution that declares that owners possess, use and dispose of land and other natural resources freely, "unless it harms the environment and infringes on the rights and legitimate interests of other persons." Another comprehensive law is the "Law on Environmental Safety" (1995). It addresses both field and main oil and gas pipelines (DNV, 1998). Unfortunately, it was not possible to obtain much detail about any of these laws. However, the new environmental legislation appears to include stricter requirements than in the past, while providing incentives for the private sector to contribute to improve environmental safety (DNV 1997).

3.25 In addition to the mentioned laws of a comprehensive nature, there are several laws regulating particular areas:

- ?? "On Air Protection" (1980)
- ?? "On the Protection of the Public and Territories from Natural and Industries Emergencies" (1984)
- ?? "On Sanitary and Epidemiological Security of the Public" (1993)
- ?? "On the Fundamentals of Urban Development in the Russian Federation" (1992)
- ?? "On the Fundamentals of Forestry Legislation in the Russian Federation" (1993)
- ?? "The Water Code of the Russian Federation" (1995)
- ?? "On Territories under Special Protection" (1995)

3.26 Attached to these laws, are more detailed instructions and regulations for many activities. Most of the relevant instructions and regulations appear to have been adopted by the State Committee on Ecology of Russia (the Ministry of Environment Protection and Natural Resources) (DNV, 1998). They include the following:

- ?? "Provisional Procedure of Assessing and Compensating for the Damage Inflicted on the Environment as a Result of an Emergency" (June 27, 1994, Regulation No. 200? Or…? An additional procedure on "The Methodology of Estimating Environmental Damage In Case of Main Oil Pipeline Emergencies" was adopted by the State Committee on Ecology and the Ministry of Fuel and Energy in 1995.
- ?? "Instructions for the Identification of the Source of Water Pollution with Oil" (August 2, 1994, Regulation No. 241).
- ?? "The Methodology of Establishing Damage from Soil and Land Degradation" (July 11, 1994).

- ?? "Rates for Calculating the Size of Penalty for the Damage Inflicted by Legal Entities and Individuals, for the Destruction of Plants, Mushrooms, Mammals, Birds and Animals" (approved by the Ministry of Environmental Protection and acknowledged by the Finance Ministry of Russia, registered with the Ministry of Justice of Russia under Regulation No. 592, dated June 6, 1995.

3.27 It seems that emphasis lies on civil and public liability (compensation issues and penalties), not on preventative considerations. Apparently, environmental impact assessments (EIA) are not required in connection with the consequences of oil pipeline ruptures (DNV 1997).

3.28 In addition to the above list, other Federal bodies have adopted instructions and regulations with regard to damages (DNV, 1998).

- ?? "On Approving the Procedure of Establishing Charges and the Limit Charge for Environmental Pollution, Waste Disposal and Other Types of Hazardous Impact" (1992), adopted by the Russian Federal Government.
- ?? "Provisional Methodology of Estimating the Damage Inflicted on Fish Reserves as a Result of the Construction, Renovation, Expansion of Companies, Built Structures and Other Projects and Various Kinds of Activities at Fishery Water Courses and Ponds" (1990), adopted by the State Nature Protection Committee and the USSR Ministry of Fishery.

Institutional Framework

3.29 Federal responsibility for protecting the enviro nment rests for a large part with the Russian Federation State Committee on Ecology (also called the Ministry of Environmental Protection and Natural Resources).

3.30 The main task of the committee is overall control of environmental protection. The control is carried out through a system of licensing and through regulating emissions and discharges of harmful substances. The committee also monitors compliance with environmental legislation (DNV , 1998).

3.31 Other federal bodies are involved in environmental aspects of oil pipelines in the Russian Federation, as listed below (DNV, 1998).

- ?? **The Russian Federal Ministry of Agriculture**, responsible for the recovery of soil fertility and the implementation of environmental protection measures. It also has the responsibility for monitoring and supervision of compliance with regulatory acts and the implementation of plant protection measures, as well as maintaining and increasing the productivity of fishing water courses and ponds and other measures.
- ?? **The Russian Federal State Sanitary and Epidemiological Supervision** Committee, responsible for supervising measures to prevent and eliminate harmful industrial emissions and waste in surface and ground water, soil, air.
- ?? **The Russian Federal State Committee on Hydrometeorology and the Monitoring of Environment,** responsible for arranging and operating the state system of monitoring the condition of environmental conditions.
- ?? **The Russian Federal Ministry of Natural Resources**, responsible for monitoring the use of, subsoil, water, and other natural resources.
- ?? **The Russian Federal Forestry Service**, responsible for the protection and recovery of forests of national significance.

3.32 While there are many laws and regulations in the FSU to address pipeline operations, these laws are generally unclear and a large number of agencies (federal and state) are expected to be responsible for monitoring compliance. Furthermore, agency responsibilities overlap. The resulting is that very little monitoring is done and compliance with laws and regulations is low at best.

THE REGULATORY AND MONITORING REGIME IN CANADA

Introduction

3.33 Unlike the FSU countries, there are many different regimes for monitoring and regulating oil pipelines in the West (particularly Canada), depending on the type and size of the pipeline and the content being transported. These regimes are comprehensive and are acclaimed for providing high safety standards. Information on the regulations can be easily accessed.

SAFETY ASPECTS OF THE CANADIAN REGULATIONS

General

3.34 The National Energy Board (NEB) of Canada is responsible for promoting safety and making regulations with regard to the design, construction, operation, and decommissioning of pipelines. NEB was established in 1959 by section 48 of the National Energy Board Act. NEB regulates over 39,000 kilometers of pipeline that cross interprovincial or international boundaries of all the provinces and territories west of the Atlantic region (NEB 1998).

3.35 Causes of oil spills (including mechanical failures, operational, corrosion, natural hazards and third party activities) are addressed through requirements for the design, construction, operation, and decommissioning of pipelines.

3.36 The primary responsibility for the safety of pipelines rests with the facility owner. To ensure that companies design, construct, operate, and decommission their facilities in a safe manner, the NEB assesses pipeline and facility applications, develops and maintains regulations, conducts regular safety inspections, and audits and investigates accidents.

Pipeline and Facility Applications

3.37 Companies that are subject to the NEB's jurisdiction must apply to the board prior to constructing or modifying their facilities. In its examination of pipeline and facility applications, the NEB considers relevant safety issues. It determines whether a proposed project meets regulatory requirements, and may examine issues such as the suitability of a proposed design, construction techniques, materials, and control systems, and the susceptibility of a pipeline to problems such as frost heave or slope instability. The NEB may reject an application or attach conditions to its approval.

DEVELOPMENT AND MAINTENANCE OF REGULATIONS

Onshore Pipeline Regulations

3.38 The Onshore Pipeline Regulations (OPR) set out minimum requirements for all stages of a pipeline's lifecycle. The Canadian Standards Association pipeline standards (CSA pipeline standards) provide a technical basis for the OPR by setting out the minimum technical requirements for the design, construction, operation, and decommissioning of pipelines. The

NEB participates with industry and other government agencies in the development and maintenance of these standards. If the NEB finds that a CSA pipeline standard requirement is not sufficient for the pipelines under its jurisdiction, it may impose more stringent requirements within its own regulations. Copies of the OPR are available through the NEB's Publications Officer or Library.

Pipeline Crossing Regulations, Parts I and II

3.39 One of the principal threats to pipeline integrity is the damage caused by third parties during excavation and construction activities. The NEB's Pipeline Crossing Regulations, Parts I and II, address this concern by establishing specific responsibilities for persons intending to conduct excavation or construction activities near pipelines, as well as the responsibilities of pipeline companies. The regulations require companies to establish ongoing awareness programs to inform the public of the presence of pipelines.

3.40 "Excavation and Construction near Pipelines" and "Living and Working near Pipelines" are guides published and regularly updated by the Board. These brochures are distributed to pipeline companies, contractors, utilities, landowners, and the public, and are available through the Publications Officer, the Engineering Branch, or the NEB Library.

SAFETY INSPECTION AND AUDIT PROGRAM

Pipeline Facility Inspections

3.41 The NEB conducts regular on-site safety inspections of the pipeline systems under its jurisdiction. NEB inspection officers are empowered to issue orders that could require a company to suspend hazardous activities, take measures to ensure the safety of the public and company employees, or take measures to protect property and the environment. The NEB may also, if considered necessary, order a company to repair, reconstruct, or alter a part of a pipeline. The NEB may further direct that until such work is done, the part of the pipeline in question is not to be used, or is to be used only in accordance with terms and conditions specified by the NEB.

Construction Inspections

3.42 Following the approval of pipeline facility applications, NEB inspection officers may conduct field inspections during the construction phase. Construction inspections provide a measure of a company's compliance with regulatory requirements, with approved specifications and procedures, and with the terms and conditions set out in the approval certificate or order. When construction is completed, the NEB may require companies to apply for leave to open their pipeline facilities for service. This leave is only granted by the NEB when it is satisfied that the pipeline may be operated safely.

Pipeline Crossing Audits and Inspections

3.43 The purpose of these audits is to determine the level of inspection performed by pipeline companies after the pipeline begins operating, the awareness of local landowners and contractors about the precautions necessary for work around pipelines, the level of communication between all parties, and the general control of construction sites. This allows NEB staff to meet with contractors, facility owners, and pipeline company field personnel to discuss the regulations, to clarify public awareness responsibilities, and to follow up on any violation of the applicable regulations.

Documentation and Safety Audits

3.44 Documentation and safety audits are conducted at company offices to review procedures and records, to verify compliance with the regulations, and to address any safety issues. Audits examine operations and maintenance manuals, emergency procedures, safety training programs, inspection, maintenance and training records, and other company practices. Each company under the NEB's jurisdiction is currently audited every two to four years. Audits may also be conducted in response to specific operational issues.

Human Resources Development Canada

3.45 The NEB and Human Resources Development Canada have entered into an agreement whereby NEB staff administer Part II of the Canada Labour Code for pipelines under the NEB's jurisdiction. This permits the designation of certain NEB staff members as Safety Officers for the occupational health and safety of pipeline company field staff. These health and safety duties are performed in combination with the NEB's own safety program.

PIPELINE ACCIDENTS

Accident Investigation

3.46 Accident investigations are an important part of the NEB pipeline safety program. Even relatively minor accidents can provide an indication of the condition of a pipeline and may suggest noncompliance with a regulation, or the need for improvements to the policies and practices of the company, or the NEB's safety programs.

3.47 Procedures in response to a reported accident depend on the severity of the accident. For less significant accidents such as minor gas leaks or oil spills, the NEB normally accepts a company's report without on-site investigation. For major accidents involving serious injury or the release of large volumes of oil or natural gas, the NEB normally conducts detailed on-site investigations and may produce a report containing its findings and recommendations.

3.48 Should recurring similar accidents or a major accident cause concern about a company's safety practices or facilities, meetings between the company and NEB staff may result. An accident file is not closed until the NEB is confident that all reasonable corrective measures have been taken to prevent future similar accidents.

Accident Reporting

3.49 Companies are required to immediately report to the NEB any incident involving the construction or operation of a pipeline which results in a fatality or injury requiring hospitalization, a fire or explosion, an oil spill, a pipeline rupture, or any other failure or malfunction of the pipeline. The NEB maintains a 24-hour reporting line for companies so that NEB staff can be contacted directly if necessary.

Transportation Safety Board of Canada

3.50 Accidents that occur during the operation of a pipeline must also be reported to the Transportation Safety Board of Canada (TSB). If the TSB decides to conduct an investigation, the NEB is prohibited from making findings as to the cause and contributing factors of the accident. However, the NEB may still investigate an accident to ensure that its regulations were not violated or to determine the need for remedial action.

3.51 The TSB has the authority to issue recommendations to the Minister of Natural Resources on ways to eliminate or reduce safety deficiencies. The NEB may be required to develop a response for the minister on the recommendations, and to advise the minister on what has been done to address the safety issue(s). Such responses can include the results of a NEB study, an assessment of the need for further work, and any regulatory response taken by the NEB.

ENVIRONMENTAL ASPECTS OF THE CANADIAN REGULATIONS

3.52 The NEB is also responsible for environmental matters relating to the construction and operation of interprovincial and international pipelines and international and designated interprovincial power lines, the export of energy, and frontier oil and gas activities within its jurisdiction. This includes ensuring environmental protection during the planning, construction, operation, maintenance, and decommissioning of energy projects. The specific legislative acts under which the NEB exercises its environmental responsibilities are the National Energy Board Act (NEB Act), the Canada Oil and Gas Operations Act (COGO Act) and the Canadian Environmental Assessment Act (CEA Act). After the Canada Transportation Act came into effect on July 1, 1996, the NEB's jurisdiction was broadened to include pipelines that transport commodities other than oil or natural gas (NEB 1998).

3.53 To discharge its responsibilities and protect the public interest, the NEB has developed procedures. The Board has also established Guidelines for Filing Requirements ("the Guidelines") which set out the kinds of environmental information that should be considered by an applicant in making a project submission. The Guidelines have been in effect since 1976, and were updated in 1995 to incorporate the environmental assessment requirements under the CEA Act.

3.54 The NEB's environmental activities are carried out in three distinct phases. The first phase involves evaluating the potential environmental effects of proposed projects through environmental assessments and, where applicable, the establishment of terms and conditions to avoid, mitigate, or compensate for possible adverse effects. During this phase, the NEB ensures that its assessments are coordinated with those of other responsible regulatory authorities, both to avoid duplication and to streamline the regulatory process.

3.55 During the second phase, the environment is protected through the monitoring and enforcement of terms and conditions attached to the project approval. This involves site inspections during project implementation. For example, inspection could occur when a pipeline or facility is under construction or while a well is being drilled.

3.56 The final phase is the ongoing, long-term monitoring of operations. This ensures the cleanup, restoration, and maintenance of project sites and rights-of-way to acceptable standards. It is also directed at ensuring that operators have effective emergency response plans in place and that the operator or the NEB can respond immediately to any incidents.

3.57 The NEB procedures are explained in more detail in Appendix C, and the matrix below summarizes the difference between the legal and regulatory frameworks of Canada and the FSU.

Comparison of Regulatory and Monitoring Regimes for pipeline operations in Canada and FSU

Framework	FSU	Canada
A. Legal Framework		
?? **Safety Standards and Regulations**	Governed by the Law on the Industrial Safety of Hazardous Production Facilities of 1997. This law is supported by several regulations, standards, and norms established during 1983–86. Process of monitoring compliance is highly fragmented and convoluted, and is implemented by several agencies including Gosgortekhnadzor (the Federal Mining and Industrial Supervision agency), Gosstandard (the State Standards Committee), and the State Construction Committee.	Regulation of pipeline safety is governed by the National Energy Board (NEB) Act of 1959. It is supported by the Onshore Pipeline Regulation (OPR) that covers all requirements for pipeline operations.
?? **Industry Standards** that govern the requirements for pipeline constructions, execution, work standards, and quality assurance of pipeline materials and general corrosion proofing	Several standards and norms have been issued. These standards are more for informal guidance to pipeline operators than strict guidelines, and hence they are not monitored.	The Canadian Standards Association (CSA) pipeline standards provide the minimum technical specifications for design and construction, operation, and decommissioning of pipelines. These specifications are mandatory and are monitored for compliance by the OPR.
?? **Environmental Aspects**	Governed by two main laws: the Law on Environmental Protection (1991) and the Law on Environmental Safety (1995). Both are administered by the State Committee of Ecology, which has issued several regulations to support the laws.	Legal framework for environmental issues is governed by the NEB Act, the Canadian Oil and Gas Operations Act (COGO), and the Environmental Assessment Act (CEA) within the NEB Act
B. <u>Institutional Framework</u>		
?? **Quality Assurance of Pipeline** ?? **Safety and the Environment**	Primary responsibility of ensuring pipeline safety rests with the pipeline owners and operators. Gosgortekhnadzor and Gosstandards oversee the issuance of licenses for the construction of pipelines, and technical evaluations of	Under the NEB Act, the NEB is empowered with the authority to assess the safety of pipelines and facilities; to develop and maintain regulations to conduct safety inspections and audits; to investigate

	safety requirements. Assurance of environmental safety is administered by the State Committee of Ecology and five other federal bodies.	accidents when they occur; and to monitor pipeline safety, including the contingency plans of the pipeline owners to contain spills. Environmental safety monitoring is the responsibility of the NEB.

4

Contingency Methods for addressing Pipeline Oil spill in FSU

4.1 In this chapter, pipeline oil spill contingency resources in the FSU are outlined (plans, capacity, and so forth). This outline is largely based on information from the 113 selected oil spill occurrences used in this report, most of which occurred in Russia.

RESPONSIBILITIES AND ORGANIZATION

4.2 As mentioned in Chapter 4 (section 4.2.2), the pipelines in the FSU can be divided into trunk systems and local systems. Trunk pipelines are mostly operated by Transneft, a state-controlled company that was responsible for oil deliveries across the former USSR. Total length controlled by Transneft is 48,000 kilometers, with 403 pumping stations. In addition, Transneft possesses 800 oil storage tanks with total volume of 13 million cubic meters. A few trunk pipelines belong to local operators. An example is the Sakhalin-Komsomolsk line, which is controlled by Sakhalinmorgetegas, a firm exploring on Sakhalin Island in east Russia.

4.3 The Transneft trunk pipeline system is structured into several area departments, often covering several federal districts of Russia. Each area department consists of a number of Regional Oil Directorates (RNU) each having its Line Production Dispatch Service (LPDS). A RNU typically operates 100–150 kilometers of the pipeline, one pump station, and a tank farm. Serious ruptures are detected as a pressure drop at the LPDS. However, smaller leaks cannot be detected in this manner. According to internal Transneft procedures, pipe walkers should regularly inspect the trunk pipeline. The tools and resources for emergency monitoring and elimination at the trunk oil and product pipelines include the following:

- ?? 15 central emergency and recovery services;
- ?? 3 specialized emergency elimination departments;
- ?? 192 emergency and recovery points; and
- ?? 2 emergency and recovery trains.

4.4 These are equipped with excavating machines, bulldozers, accessories, tools, and other required equipmentfor eliminating the consequences of accidents and emergencies. These subdivisions carry out routine monitoring of the conditions of oil pipelines and scheduled and prevention repairs.

4.5 Local pipelines transport crude oil from wells through processing and storage facilities to the trunk pipeline. Local pipelines belong to the production unit (NGDU) and spills from such pipelines are the responsibility of the local operator. The total length of local pipelines greatly exceeds that of the trunk pipelines, and local pipelines have much lower reliability and many more spills.

RESPONSE METHODS AND EQUIPMENT

4.6 Complete information is available on 113 oil spill incidents from FSU pipelines from 1986 to1996. The reported spills are all large, with oil quantities in the order of thousands of tons. Cleanup efforts have been reported for only 65 of these spills, or about 57 percent of the incidents. In another 29 of the spill incidents, the oil was unintentionally ignited, limiting or totally precluding oil recovery operations.

4.7 For 17 spills no response effort or burning was reported. Taking this into account, approximately 15 percent of the inc idents were left unattended. Even though this figure may partly reflect a lack of detail in the spill reports, in many spills, according to unofficial reports, there was no attempt to clean up the spilled oil. Estimates of spill frequency vary greatly, with numbers ranging from several hundred to thousands of spills per year from the trunk lines. For local pipelines much higher spill frequencies have been reported, with up to 0.7–0.9 incidents per pipeline kilometer per year for the fields in Ural-Povolzhyie and Bashkiria. By contrast, pipeline failure rates for Europe and the United States are estimated at .005–.006 incidents per pipeline kilometer per year. Another example is the Maiskneft Oil and Gas Extraction Department, operated byYukos, the second largest petroleum producer and petrochemical company in Russia. The Maiskneft NGDU had 178 oil pipeline ruptures in 1994, which resulted in 5,262 metric tons of earth oiled. According to data of the Federal Mining and Industrial Supervision of Russia (Gosgo rtekhnadzor), over 40,000 failures a year take place in the northern oil fields of Russia alone. Most of these failures are due to internal pipeline corrosion.

4.8 Table 4.1 shows the number of spills for each te rrain area, and as a percentage of the total number of spills. Brackets indicate the number of incidents for which combat efforts have been reported. Note that several areas may have been affected in a single accident.

Table 4.1. Areas Affected by Pipeline Oil Spills in 113 Historical Incidents

Area type affected	*Number of incidents*	*Fraction of total (% of 113)*
Land	111 (65)	98
River	30 (21)	26
Sea	2 (1)	2
Ice/snow	7 (6)	5

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

4.9 In almost all the reported spills the initial contamination occurred on land. In about every fourth incident oil drained to nearby rivers. In a few cases contamination of ice and snow has been reported. Clearly an oil spill response system must focus on the removal of oil from the ground, methods to prevent oil drainage to rivers, and on-water recovery in rivers. Methods adopted are listed in Table 4.2 below. Note that several methods may have been used in a single accident.

Table 4.2. Oil Spill Response Methods Applied in 65 Pipeline Oil Spills

Response method	*Mechanical*	*Manual*	*Berming*	*In-situ burn*	*Bio-remediation*
Number of incidents	46	5	17	8	1
Fraction of total (%)	71	8	26	12	1.5

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997

4.10 **Mechanical methods:** This class includes all responses that rely on the use of skimmers, booms, pumps, or heavy machinery such as trucks, bulldozers, and excavators.

Manual: This involves the use of sorbents to remove the oil selectively or shovels to remove contaminated soil, gravel, and so forth. Presumably this response class is highly underreported here. It is likely that some type of manual recovery was part of most mechanical recovery methods.

Berming: This involves the construction of dams or berms to contain the spill at the emergency location or to prevent oil from reaching rivers or other bodies of water.

In-situ burning: This method involves burning of oil at the spill location. This must be distinguished from unintentional ignition, which occurred in about 25 percent of the spill incidents.

Bioremediation: The controlled use of bacteria to promote natural degradation of the oil.

In the following sections some common cleanup methods for on-land spills are described, along with discussion of the extent to which these methods are used in the FSU.

Excavation and disposal

4.11 Excavation and disposal involves removal of contaminated earth using heavy construction machinery like excavators and bulldozers. The method is considered very costly and disruptive and usually creates a disposal problem. Disposal methods for contaminated soil include landfarming, landfilling, and incineration. Landfarming involves the controlled application of oil-contaminated soil to an area and the promotion of naturally occurring microbial aerobic biodegradation. Landfilling is generally the least expensive and easiest method. However, decomposition may be slow due to a lack of spreading, aeration, and nutrition. Incineration can be an efficient and fast method of disposing contaminated material. Its disadvantages are emissions and residual ash, which often contains most of the heavy metals. These metals must be recovered and disposed of safely.

4.12 Excavation and disposal has been reported for several of the spills in the FSU. The reports indicate relatively good availability of bulldozers, excavators, and other heavy construction machinery. Reports rarely include any information on the disposal method used but merely note that contaminated soil was removed. In several cases incineration has been used to deal with the contaminated material after removal from the spill site.

Trench/drain/sump systems

4.13 When a spill occurs in a shallow groundwater system, interception and recovery of oil can be accomplished by excavation of a trench across the path of the plume. Oil that accumulates on the water surface of the plume can be recovered using an oilskimmer, a vacuum truck, or sorbents. An impermeable barrie to oil may be used on the outflow side of the trench to prevent unrecovered oil to flow through.

4.14 This method reportedly was used in a few of the 113 FSU oil spills. However, none of the reports mention the use of oil skimmers in the pit. The limited information available may indicate that pumping directly from the pit is the prevailing method.

Dewatering/recovery well systems

4.15 This method involves drilling of a well and is used when the ground has adequate flow properties. Control and containment of the plume is accomplished through the establishment of a "cone of depression," which is a sink that is created by pumping water from the well, thus lowering the groundwater level locally. Oil will flow to the well location. The method is considered less disruptive then excavating a trench and is often more effective. None of the reports indicate that this method was applied to any of the FSU spills.

In-situ burning

4.16 This method, which involves ignition and burning of the oil at the contaminated location, can be an effective means of dealing with oil spills. In-situ burning is not a frequently used measure in Western countries due to hazards to people and installations and concerns about emissions.

4.17 In-situ burning has been applied quite often as an on-land response method in FSU. Unintended ignition and burning of the oil spills also occurred in about 25 percent of the incidents.

Berming

4.18 In about 25 percent of incidents, dams or berms were built to contain the spill at the emergency location or to prevent oil from reaching rivers or other bodies of water. In some cases contained oil was removed from the dams using skimmers or pumps. However, in several spill cases the erection of berms appeared to be the only containment action, with no measures noted for the removal of oil accumulating in the dams.

Skimmers and booms

4.19 The use of booms and skimmers is considered the backbone of any on-water mechanical oil recovery operation. Only about 15 percent of response operations reported the use of such equipment. This may partly be due to lack of details in the spill reports. However, it appears that the availability of such standard mechanical recovery equipment is limited.

RESPONSE ACTION ABILITY

4.20 Spill incident reports do not give any information regarding the efficiency of the containment actions or to the disposal of the oil residue collected. Furthermore, the data seems to illustrate that the chance availability of resources dictated cleanup methods used, rather than preparation and training for particular contingencies.

4.21 For 9 spill incidents (or 15 percent of the 65 incidents that reported cleanup efforts cleanup involved the use of dedicated oil spill response equipment. For the other incidents, equipment on hand, as excavators, spades, and so forth, made up the main spill resources. These numbers reflect to some degree the various types of incidents, but they also underline what has been reported by other sources, namely that spill response in the FSU lacks structure in the form of plans and dedicated equipment.

CONTINGENCY PLANNING AND CAPABILITY

4.22 Oil spill contingency plans are described in detail in Appendix B. The effectiveness of FSU countries' responses to pipeline oil spills are summarized in Chapter 6.

5

Oil Spill Contingency Capability

5.1 This chapter discusses the estimated cleanup capability of FSU countries, based on a review of previous contingency responses.. These responses are outlined in Appendix B and include the following details:

?? equipment and methods available;

?? plans and their applicability;

?? availability of exp erienced and trained crews; and

?? general organization of operations and its impact on oil spill contingency.

5.2 To illustrate the general state of oil spill contingency plans in the FSU, an evaluation of the response to a 1994 incident in the Komi republic, for which information is available, is discussed below. This discussion illustrates the general applicability of lessons learned from this incident to the oil spill contingency program in the FSU.

General Response to Oil Spill incidents in FSU

5.3 The vast majority of reported incidents in the FSU have occurred in the Russian Federation. Under the Law on Industrial Safety of Hazardous Production Facilities (adopted from former USSR regulations), organizations operating hazardous production facilities such as pipeline systems are required to prepare for emergencies and to have response plans for minimizing the consequences of such emergencies. The legislation also specifies preventive measures such as required procedures for component certification, design, construction, operation, and maintenance of pipelines. However, there was no cleanup effort for approximately half of the reported incidents, , and it seems that there is no correlation between the size of the spill and the initiation of cleanup actions. This indicates a lack of organized contingency response, as previously discussed. Furthermore, the laws only focus on the technical aspects of spill containment and do not address environmental assessment issues. This observation applies to the other FSU countries.

Methods

5.4 Methods to address leakage or spills should ideally be decided upon prior to an incident. This ensures that plans, materials, equipment, and personnel for confronting such incidents are readily available. However, this is not the case in Russia or the other

FSU countries. As mentioned above, the method for responding to a spill is more a function of what is at hand rather than what is appropriate.

5.5 The main methods for responding to oil spills include that following:

- ?? *in situ burning.* The spilled oil is burned on site.
- ?? *Bioremediation*. This involves mixing the spilled oil with the soil, introducing bacteria that can digest the oil and reduce its concentration, and allowing natural forces to further degrade the toxicity of the oil.
- ?? *Berming.* Impervious barriers are erected to trap the spill, which is then collected or scooped up. This process is used mainly for spills that occur on rivers or lakes; the berms hinder the oil from spreading into river channels.
- ?? *Mechanical methods.* These involve physical excavation of the soil (with the oil). The excavated soil is then either heated in furnaces to separate the oil or the oil is leached out.

5.6. These methods could be used separately or in combination. However, the type of method used is dependent on the volume of the spill, characteristics of the oil, and the nature of the environment.

5.7 In the FSU countries (including Russia) the preferred method of cleanup is in-situ burning. This method is not often used in most industrialized countries because the fumes and emission could be hazardous to the health of the surrounding population and also the environment. In-situ burning is used in industrialized countries only if the other methods are considered not applicable or ineffective, and the volume of oil is small. The in-situ method might be used in a cold environment, such as in snow, where mechanical excavation is not appropriate; burning could also be used offshore where the oil is emulsified (that is, mixed with water). Generally, in industrialized countries, the mechanical method is preferred for spills on land and is often followed with bioremediation. For spills on water (rivers, lakes, or larger expanses) the berming technique is applied, and could be followed with in-situ burning.

5.8 Although reports in FSU show that in-situ burning has been highly successfulfor treating spills, this has been difficult to verify because of the paucity of recorded data on such activities. The Komi incident is a good illustration of the level of negligence and the lack of rapid response capability of the Russian system.

THE KOMI INCIDENT

5.9 The Komi spill differs from other incidents with respect to available information, due to the involvement of the international community. After several spills in the Komi republic during the autumn of 1994, the Russian authorities requested assistance through the United Nations (UN).

5.10 A mission of experts appointed by the UN was sent to the effected area in early December 1994. See UN (1994) for the findings and conclusion of the work of the expert group.

Situation review

5.11 A series of spills from the pipeline in the Vozey/Usinsk area of the Komi republic created major international concern during September–December of 1994. A number of spills were known to have occurred, and due to neglect or lack of adequate response, the spills polluted the environment with hydrocarbons over a considerable timeframe. The spill size was estimated at 93,000–97,000 cubic meters of partly emulsified oil, covering an area of 600 acres at the time of the UN mission. These figures represent the remaining oil after many years of leakage into rivers and to lakes. By comparison, 2001 Fairbank spill on the Trans-Alaska pipeline, often referred to in literature as a large terrestrial crude oil spill, affected only 2.1 acres and required a 63-day cleanup operation.

5.12 In the Komi republic, the oil resulting from years of minor and more substantial leakage—leakage which occurred with increasing frequency towards the end of 1994—were taken care of by building berms in the rivers or creating oil lakes. Following a period of forceful rain during the autumn of 1994, some of these dams collapsed in October 1994, spreading oil over a large area and affecting the river system. Eventually, oil collected in the locations listed below:

- ?? Oil was entrained in natural indentations in the terrain (forming one identified lake containing approximately 80,000 cubic meters.
- ?? Oil collected above ice level alongside rivers.
- ?? Oil accumulating up to 60 centimeters in thickness under ice in rivers.
- ?? More than 90 percent of the spill was localized to four rivers and to the above-mentioned lake.

5.13 The Komi situation was significant both due to the considerable size of the spill and the complexity of deciding the appropriate contingency method to apply.

Measures adopted

5.14 Prior to the 1994 UN mission and other international aid, there seem to have been no contingency measures for coping with the effects of emergencies like the Komi spill . The only action taken was to build up berms and lakes for temporary depositing as the spills occurred.

5.15 Following the UN mission, a fairly detailed assessment of the affected area was carried out. The area was divided into specific geographic and environmental categories for the application of several cleanup strategies.

Rivers

5.16 Since the oil had a gum-like consistency, it stuck onto the ice-covered riverbanks. This oil could be easily scraped off the ice using hand tools and carried away after collection in containers. The ice on the river facilitated the implementation of this strategy by having sufficient strength to allow snowmobiles and tractors on it. It was suggested by the UN delegation that 20–30 men should be able to clean up the majority of the riverbanks during a period of two to three weeks.

5.17 For the oil trapped under the ice, holes had to be drilled to allow the oil to be pumped out. This process required the use of excavators, heating facilities to bring the oil to a viscosity the could be pumped, a means of separating oil from water, on-site storage facilities, and containers to transport the oil out of the region.

Areas with large concentrations of oil

5.18 Previews leakage in the Komi incident was contained by large, excavated areas (oil-lakes) that trapped oil in a relatively limited area. A lake measuring 500 by 250 meters containing an estimated 80,000 cubic meters of oil was constructed. There was considerable concern that the lake could leak oil to the groundwater. The lake had no ice forma tion on the surface. The oil's consistency was reported to be gum-like and it was assumed that the use of excavators would be possible and efficient. The operator of the pipeline, Komineft, considered heating the oil, removing the water, and sending the oil back into the pipeline system. Berming was also used to prevent the oil from spreading further downstream. In the past, Komineft had constructed berms across other pipelines in anticipation of oil spills.

Conclusions of the UN mission

5.19 The general view of the UN mission was that the whole area of oil installations in the Usinsk region was affected in varying degrees. Some areas should have been prioritized for immediate action. In general, the most efficient measures were thought to be a combination of oil-mass removal, first through mechanical method and then on a finer level in combination with bioremediation.

5.20 Further, it was advised that a comprehensive contingency plan be developed, including the establishment of oil spill contingency depots, to handle potential future spills. The UN mission concluded that this responsibility should reside with the users of the pipelines, namely the oil companies. It is not evident that Russia or any other FSU country has followed the clear recommendations of the UN mission report (UN 1994a regarding the establishment of contingency plans and depots. Interviews with some UN mission members seem to indicate that these recommendations have been ignored (Kolstad, 1994), This study did not identify any contingencyplans or the development of such plans in any of the FSU countries.

5.21 The Komi spill clean up was eventually carried out in cooperation with regional authorities and private operators, and with financial assistance from the World Bank.

INDUSTRY-ACCEPTED PIPELINE EMERGENCY PREPAREDNESS PLANS

5.22 Following numerous incidents both offshore (involving ships, pipelines, exploration, and production) and onshore (involving pipeline systems, refineries, and so forth) general requirements on emergency respons e and crisis management plans were developed by several authorities.

5.23 The current Trans-Alaska Oil Spill Contingency Plan-Pipeline is an example of a plan designed to meet federal and state regulatory requirements of the U.S. government. This plan is comprehensive, and contains several volumes describing specific responses to spills anywhere along the 800-mile Tans-Alaska Pipeline System (APSC, 1995b).

5.24 However, the size of a contingency plan does not necessarily illustrate a company's ability to respond adequately to a spillage incident. The plans are often developed to meet a matrix of government regulations, rather than ensuring that they are operationally efficient. Plans based upon unrealistic expectations end up on the shelf collecting dust. Thus, the initial consideration in contingency planning should be to develop expectations based upon the availability of resources. The less developed the logistics of a region, the more realistic planning becomes.

5.25 The main components in the development of oil spill contingency plans should include examination of government regulations and interviews with crisis management professionals and organizations. Proven approaches in oil spill emergency planning generally include the following measures:

- identification and documentation of emergency incidents;
- scenario development;
- seasonal variations;
- unique conditions at site;
- specific requirements for response preparedness;
- initial response preparedness and general response preparedness;
- spillage containment and control techniques (methods);
- overall methodology;
- training, including drills and exercises; and
- equipment maintenance.

5.26 Emergency plans should also include guidelines on how to bring the affected area back to normal.

5.27 A contingency plan developed along the main directions given above, and reflecting the specifics of the region, sets up procedures capable of handling initial spills. However, some of the incidents in the FSU should be classified as constant leaks, since owners are unwilling to close down damaged pipelines due to financial considerations. This indicates that not only contingency plans are required, but also changes in attitudes and policies.

CONCLUSION ON OIL SPILL RESPONSE CAPABILITY OF FSU

5.28 The above discussion indicates that oil spill contingency plans for the FSU pipeline network lack established routines and clear policies. The plans are therefore unprepared for rapid response to spills. Although some facilities for oil spill contingencies have been identified in the Russian Federation, and facilities might be available in other FSU countries, systematic organization of vital elements is lacking. These vital elements include the following:

- scenario development;
- logistics;
- equipment and methods; and
- training and drilling.

5.29 Routines for detecting spills are failing, causing long-term leakage to the ground and surroundings. Furthermore possible financial loss due to the closure of the pipeline seems to hinder and delay effective response to spills. The decision process leading to implementation of an oil spill response seems to reflect resources at hand, rather than the most effective technique to contain the spill.

6

ASSESSMENT OF RISKS

SPILL RISK ASSESSMENT IN FSU

6.1 Risk assessment in the FSU of pipeline ruptures, including risks to the environmental from spills, was analyzed in this study on a country-by-country basis. The analysis was performed on data collected for the 113 FSU pipeline spills used in this study that occurred between 1990 and 1996.

6.2 Appendix E presents numerous oil spill statistics obtained for this study.

6.3 Comparisons between the pipeline operation experiences of the FSU and Western Europe are presented in Appendix G (CONCAWE 1998), including methods for prevention, detection, and control of spillage.

6.4 Table 6.1 and Figure 6.1 present the number of spills, spill frequency expressed as kilometer-years, and the failure rate for each FSU state. Except for Russia the number of oil spills is limited. For Georgia, Lithuania, Turkmenistan, and Uzbekistan no spills are reported. The spill frequencies for these countries are represented by lightly colored bars in Figure 6.1, because these frequencies are based on a statistical estimate of 0.7 failures (50 percent confidence in Poisson distribution for zero events).

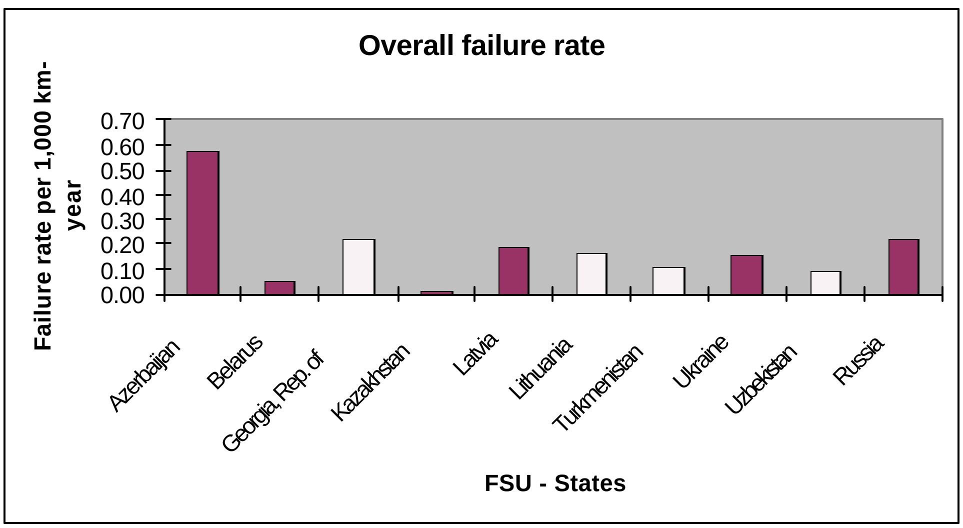
6.5 Azerbaijan has a high pipeline failure rate. This high rate could be due to good reporting of oil spills. However, the rate could also be due to other factors such as political instability (resulting a in higher risk of sabotage), the fact that the area is prone to earthquakes, or the age of the pipelines. The high failure rate could also be due to the prominence given to the installation of new pipelines and the consequent neglect of maintenance on old systems. One oil spill in Azerbaijan was definitely identified as sabotage. The ages of Azerbaijan's pipelines are unknown, but as Azerbaijan is a mature oil-producing region, a reasonable assumption is that the pipelines are older than average.

Table 6.1 Failure Rates for FSU States, 1990–96

Location	*No. of oil spills*	*Kilometer–years*	*Failure rate per 1,000 km-years*
Azerbaijan	3	5,222	0.57
Belarus	1	20,504	0.05
Rep. of Georgia	0	3,115	0.22
Kazakhstan	1	57,756	0.02
Latvia	1	5,268	0.19
Lithuania	0	4,242	0.17
Turkmenistan	0	6,328	0.11
Ukraine	5	31,773	0.16
Uzbekistan	0	7,490	0.09
Russia	101	446,681	0.23
Total	112	588,379	0.19

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Figure 6.1 Variation of Failure Rate by FSU States for All Oil Spills, 1990–96



Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

6.6 The pipeline failure rate in Belarus is low. This could be due to poor reporting of oil spills, newer pipelines, better quality of materials used, better maintenance, or less corrosive soil. When a pipeline is new or old there are often more spills occurring than in the rest of its lifetime. As stated before, this is could be due to teething troubles for new pipelines or wear-and-tear on old pipelines. The age of the pipelines in Belarus is not known and so it is difficult to speculate if they are either new or old (> 6 years).

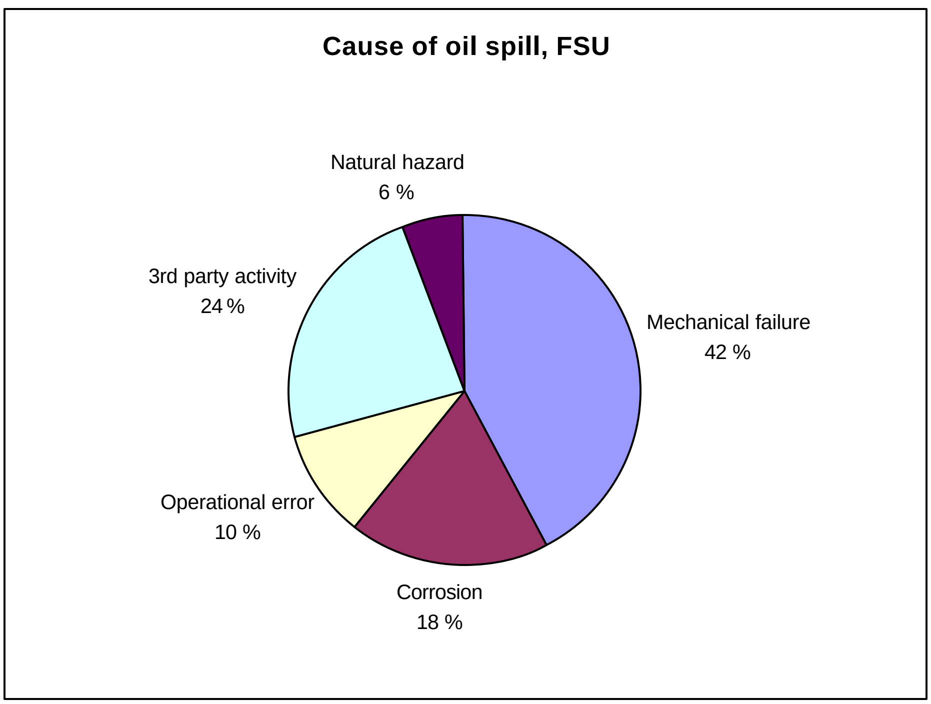
6.7 The failure rate in Kazakhstan is low. Kazakhstan is sparsely populated and therefore there is at low risk for sabotage and other third-party activity. The terrain is characterized by dry steppes, which gives low risk for external corrosion and natural hazard events.

CAUSES OF PIPELINE FAILURES

6.8 Causes of pipeline failure in the FSU have been analyzed in accordance with CONCAWE nomenclature. Figure 6.2 presents the distribution of failure causes in the FSU. Mechanical failures and failure due to third-party activity dominate the picture. Figure 6.3 presents the same distribution given by CONCAWE, 1996 for failure causes for onshore oil pipelines in Western Europe. Figures 7 and 8 show that in comparison to Western Europe, the FSU had fewer spills caused by corrosion, third-party activity, but more caused by mechanical failures and operational errors. There is no reason to believe that there should be less corrosion in the FSU than in Western Europe. The difference is probably due to poor reporting of spills. The fact that third-party activities are less common in the FSU may also be based on poor reporting or the fact that FSU is sparsely populated.

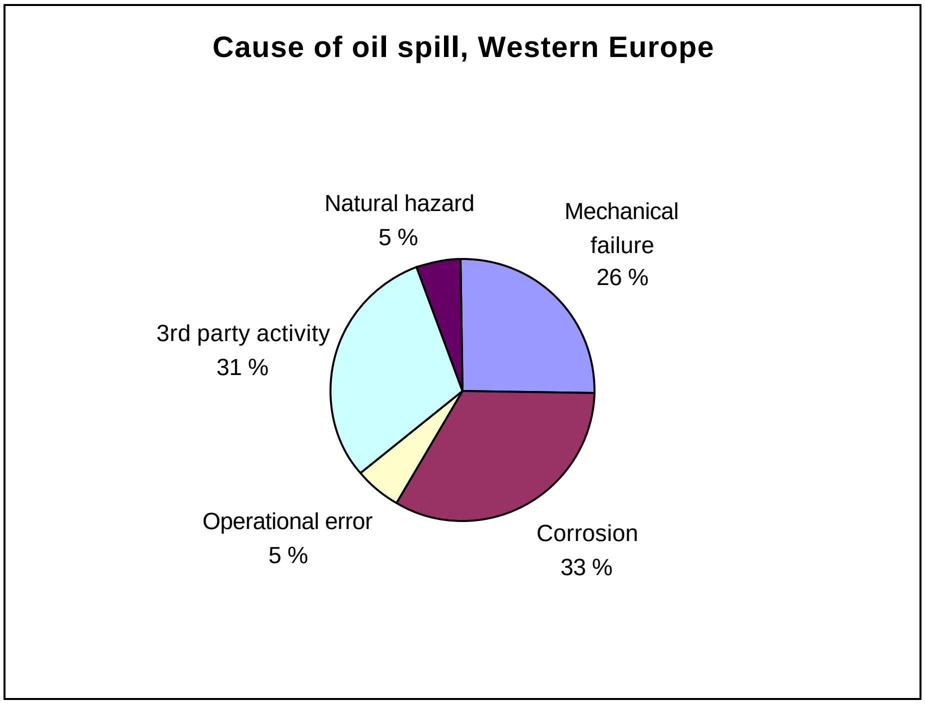
6.9 There may be more mechanical failures and operational errors in the FSU than in Western Europe. However the classification of failure causes in FSU has been done with a limited data set. Many causes that were described as "structural problems" were classified as mechanical failures, but some of them could have been related to corrosion or natural hazards.

Figure 6.2. Distribution of Causes of Oil Spills in the FSU, 1990–96



Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Figure 6.3. Distribution of Causes of Oil Spills in Western Europe, 1990–96



Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Mechanical failure

6.10 Mechanical failures are ruptures and fissures that occur when systems are overstressed. These failures can be caused by poor quality of materials or faulty construction.

6.11 Manufacturing defects can occur in the pipe (for instance, in the pipe wall) or in pipe fittings (for example, in the longitudinal weld). Poor construction techniques can generate high residual stress levels in the pipeline prior to commissioning. For example, the forming of pipe bends, welding techniques, and the handling of materials can all lead to unacceptable construction practices if not carried out according to specification. Mechanical failure accounts for about 40 percent of spillage incidents in the FSU.

6.12 In Appendix F, an approac h to pipeline design and the measures taken to prevent mechanical failure are given. In addition, measures taken during construction and commissioning are described.

Operational failure

6.13 Operational failures can be due to overpressure or malfunction of systems such as pressure relief or control devices. These failures are also caused by human error, such as ignoring correct operating instructions. Operational factors cause about 10 percent of pipeline failures in the FSU .

Corrosion

6.14 In Western Europe, corrosion has been the most common cause of spillage, although the quantities spilled in each incident are usually small due to the timely containment response. Figure 6.2 shows that over the years, corrosion was responsible for only 18 percent of the spillage incidents in the FSU as compared to 33 percent for Western Europe (Figure 6.3).

6.15 Pipelines are subject to two types of corrosion—internal and external. Crude oils and oil products can give rise to internal corrosion, usually in combination with water. Corrosion can also occur when pipelines are not in use. External corrosion occurs when the pipeline anticorrosion coating is inadequate, or when the cathodic protection is inefficient.

6.16 The majority of spills due to corrosion are caused by external corrosion.

Natural (external) hazards

6.17 Natural hazards are phenomena such as landslides, flooding, ground subsidence, and earthquakes. Appendix F contains a description of how areas susceptible to these phenomena are avoided where possible. Pipeline routing and design anticipates these hazards when they cannot be avoided, resulting in a low incidence of failure due to natural causes—about 6 percent of reported incidents in the FSU during the time frame for this study. In Western Europe, 5 percent of spills were due to natural causes.

Third-party activity

6.18 Third-party activity was responsible for about 24 percent of reported incidents in the FSU during the study period.

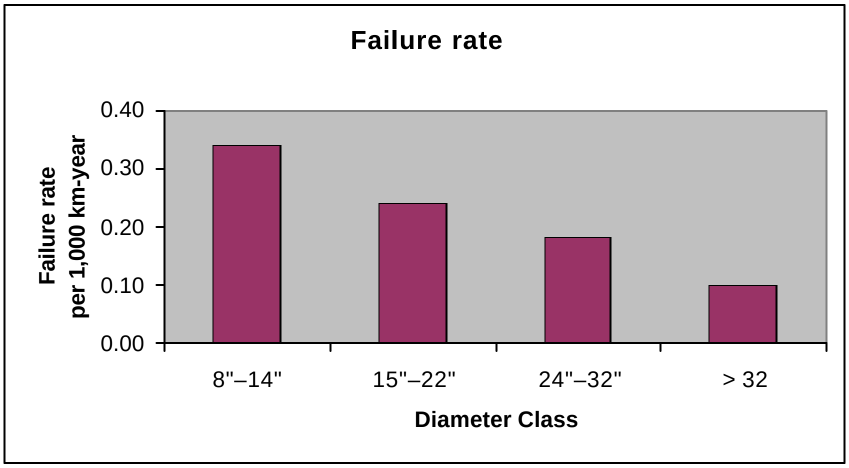
6.19 The majority of these spillages were caused by accidental damage inflicted after construction of the pipeline by third party excavation. Surveillance and inspection procedures are designed to minimize the amount of damage caused by third parties, and these are described in Appendix F.

6.20 A small number of spillages are caused by deliberate criminal attempts to steal product from the pipeline or to cause a nuisance.

Correlation of pipeline diameter to failure rate

6.21 Figure 6.4 presents the effect of variation in pipeline diameter on FSU failure rates. As expected there are higher failure rates for smaller pipelines than for large pipelines. The same trend is noticed in Western Europe. Pipeline diameters are often proportional with wall thickness; the larger the pipeline diameter, the thicker the wall.

Figure 6.4. All Oil Spills in FSU, 1990–96

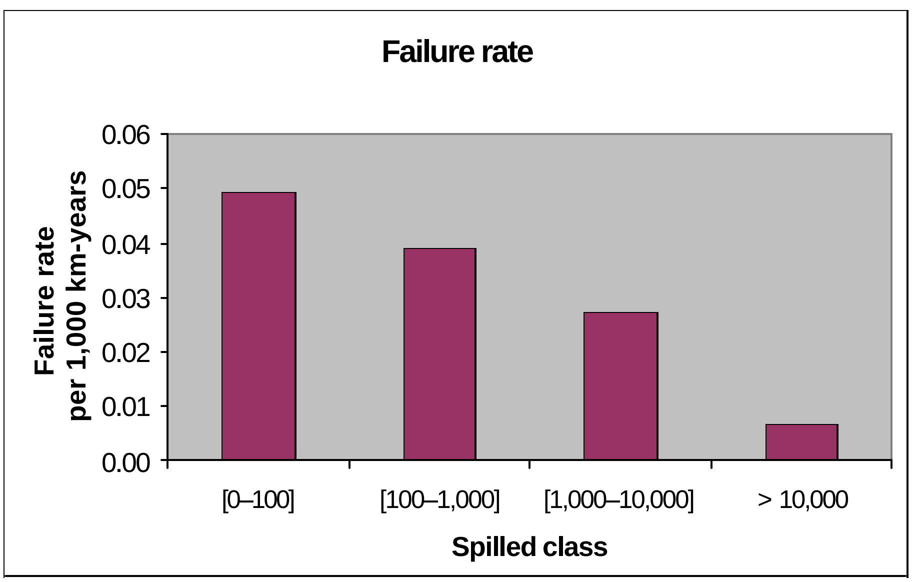


Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

ANALYSIS OF AMOUNT OF CRUDE OIL SPILLED

6.22 Figure 6.5 presents the failure rate variation by amount of oil spilled. It is not surprising that small amounts are more frequent than large ones.

Figure 6.5 Variation of Failure Rate by Amount Spilled for All Oil Spills in FSU, 1990–96

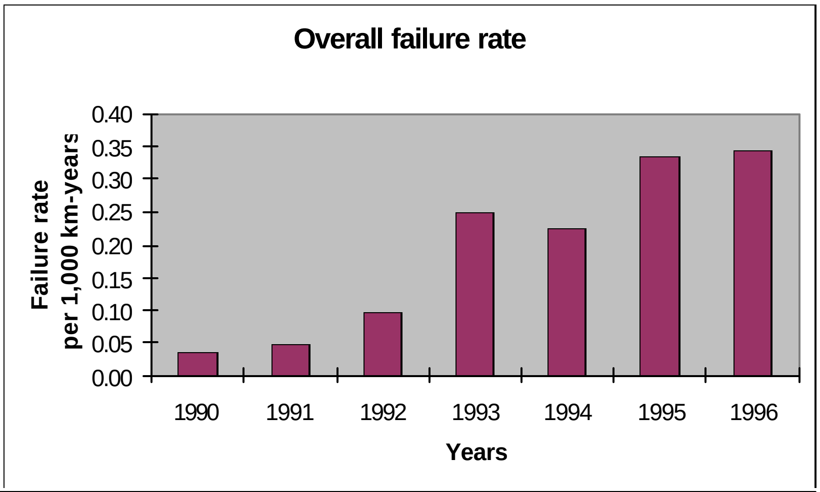


Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

VARIATION OF NUMBER OF SPILLS AT DIFFERENT PERIODS (1990–96)

6.23 Figure 6.6 presents failure rates for each year from1990 to 1996. The failure rates for the years 1990 to 1992 are low compared to the failure rates for the years 1993 to 1996. This is partly due to the fact that the oil spill data collection has been much better for the years 1993 to 1996; hence, the difference in failure rate over the years may not necessarily reflect an increasing trend, but rather the variation in the reporting of spills. Therefore, analysis of failure rates for Russia has only been performed for the years 1993 to 1996. The other states have too few spills for similar analyses.

Figure 6.6. Variation of Failure Rate by Year for All Oil Spills in FSU, 1990–96



Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

FREQUENCY OF SPILL OCCURRENCE IN THE DIFFERENT RUSSIAN REGIONS

6.24 As shown in Appendices A and B, the Russian regions (including the other FSU countries), have been divided into six geographical subregions to highlight climatic effects and to facilitate comparison between the different FSU countries.

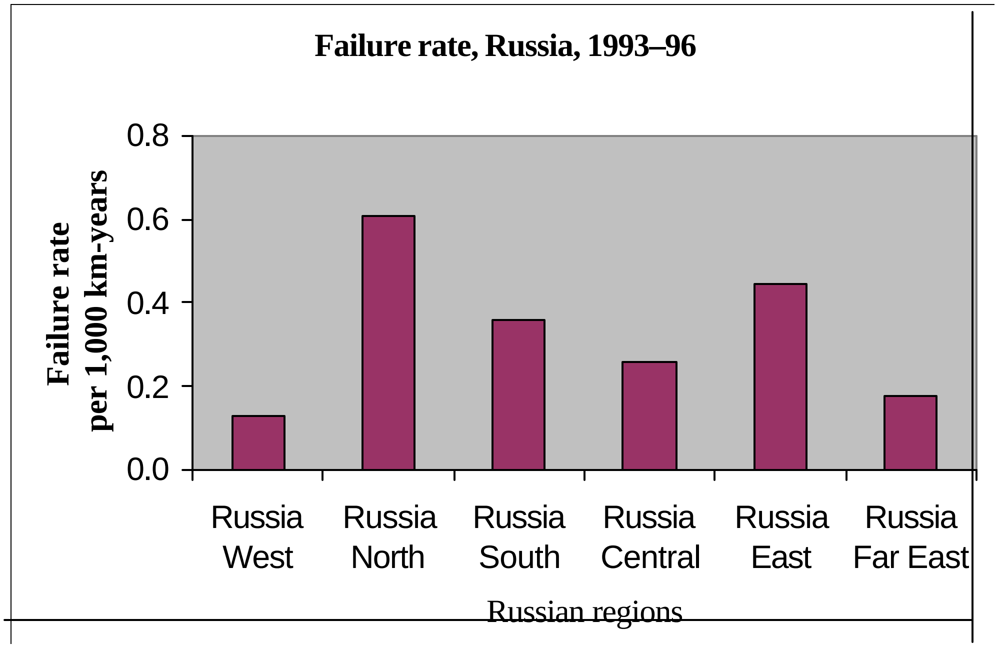
6.25 Table 6.2 and Figure 6.7 present the failure rates in these regions. In Russia North and Russia East the failure rates are higher than in the other regions.

Table 6.2. Failure Rates for Regions in Russia, 1993–96

Location	*No. of oil spills*	*No. of km-years*	*Failure rate per 1,000 km-years*
Russia West	5	31,570	0.3
Russia North	9	14,804	0.6
Russia South	13	33,405	0.4
Russia Central	19	73,100	0.3
Russia East	43	96,671	0.4
Russia Far East	1	5,696	0.2
Total, Russia	90	255,246	0.4

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

Figure 6.7. Variation of Failure Rate by Regions in Russia for Years 1993–96



Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

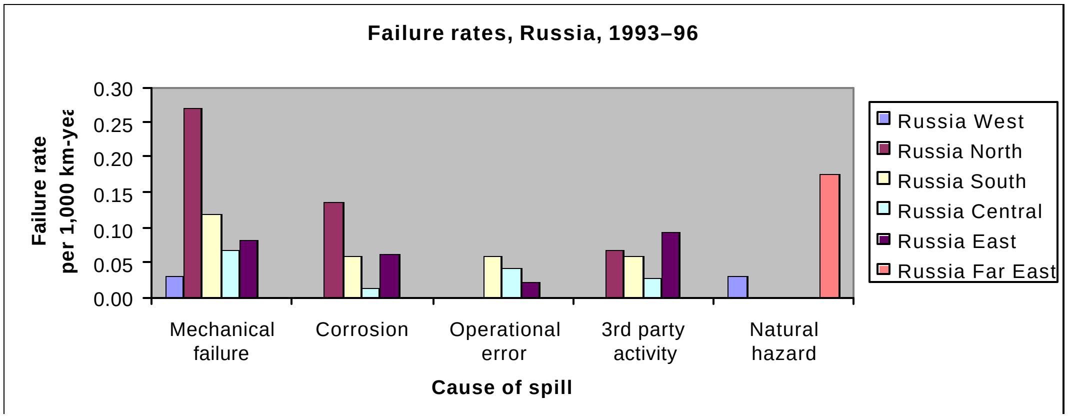
6.26 The variation between Russian regions in failure rate could be due to differences in pipeline age, routing and construction, and characteristics of the environment, or geology. It could also be due to different operators or a better reporting of oil spills. The failure rate is lowest in Russia West. This could be due to the young age of the pipelines; or construction standards may have been improved at the time these pipelines were installed. The pipeline ages are unknown. There were only two oil spill events recorded in Russia West, and hence it is difficult to be specific on the causes of failures in Russia West.

6.27 The failure rate is highest in Russia North. This may be due to the permafrost environment . A number of oil spills in Russia North are due to mechanical failures. Again, it is difficult to be specific on the causes of pipeline failures in this region; there are only seven oil spill events reported to be significant in Russia North.

6.28 The failure rate is also high in Russia East. However, it is reported that a large part of the oil spills in Russia East is due to third-party activities.

6.29 Figure 6.8 presents failure rates distributed by cause of spill for each Russian region. Russia Far East had only one oil spill with a known failure cause.

Figure 6.8. Variation of Failure Rate by Cause for Russian Regions, 1993–96

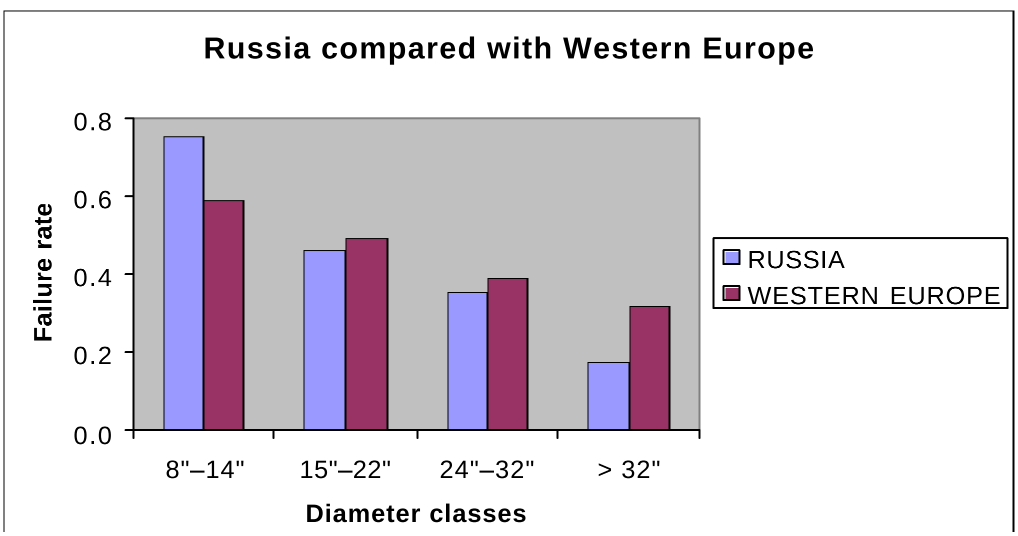


Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

FAILURE RATES IN RUSSIA COMPARED WITH WESTERN EUROPE

6.30 Table 6.3 shows the effect of the variation of pipeline diameters on failure rate in Russia. However, due to the limited data set used (85 spills) the effect of diameter on pipeline ruptures may be underestimated. For comparison, Table 6.4 shows the effect of pipeline diameters on failure rates for onshore oil pipelines in Western Europe. These data include all oil spills reported to CONCAWE in Western Europe during the years 1971–93. There are reasons to expect that the failure rates in FSU are higher than presented in Table 6.3, but it is unknown by how much..

Figure 6.9. Russia (1993–96) Compared to Western Europe by Diameters



Note: Failure rate is per 1,000 km-years.

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

6.31 Figure 6.9 compares Table 6.3 and Table 6.4. This figure illustrates that the failure rate level for Western Europe and the failure rate level based on the collected oil spills in FSU are about equal.

Table 6.3 Failure Rates for Each Diameter Class, Russia, 1993–96

Diameter class	*No. of oil spills*	*No. of km-years*	*Failure rate per 1,000 km-year*
8”–14”	6	7,939	0.8
15”–22”	30	64,623	0.5
24”–32”	33	92,629	0.4
> 32”	16	90,055	0.2
Total	85	255,246	0.3

Source: Pipeline Oil Spill Preventin and Remediation in FSU, DNV, 1997.

Table 6.4. Failure Rates for Each Diameter Class, Western Europe, 1971–93

Diameter class	*Failure rate per 1,000 km-year*
8”–14”	0.59
16”–22”	0.49
24”–28”	0.39
? 30	0.32

Note: Failure rate is per 1,000 km-years.

Source: CONCAWE-1998; *Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.*

6.32 Table 6.5 presents gross volume spillage and millions of metric tons of crude transported for the FSU. Form 1990 to 1996, the average amount spilled per 1,000 kilometer-years for the FSU (using the recorded spill sizes) was estimated as 371 metric tons. This figure may be an underestimate since only 65 percent of recorded spills included the amount of oil spilled. The figure may be as high as 571 metric tons spilled per 1,000 kilometer-years. In Western Europe the average amount of oil spilled during 1971–93 is 116 metric tons per 1,000 kilometer-years CONCAWE, 1997. Even if the large oil spill of 104.422 metric tons in Russia North is excluded, the average metric tons spilled per 1000 km-year will be 194, more than the average in Western Europe, implying that the amount of oil spilled per event is higher in FSU than in Europe.

6.33 In Western Europe the spillage oil volume per oil volume transported has been 4.4 parts per million on average for the years 1971–93. According to the registered spill sizes, the average metric tons spilled per million metric tons transported in FSU from 1990 to 1996 was estimated at 55 parts per million (but this figure could be an underestimation). Nevertheless, the conclusion is that the amounts spilled per metric tons transported in FSU are higher than in Western Europe.

6.34 Higher spill volumes in the FSU may be the result of poor contingency planning, poor detection (partly due to the large, sparsely-inhabited areas in the FSU), , longer distance between emergency shutdown valves, or larger-than-average dimensions for pipelines in FSU. All these factors should be further analyzed in the next phase of the project. Spilled amount per throughput should also be compared with Western Europe in the next phase of the project.

Table 6.5 Gross Volume of Spillage

Location	*Amount spilled (metric tons), 1990–96*	*No. of km-years, 1990–96*	*Million metric tons transported, 1990–96**	*Metric tons spilled per 1,000 km-years*	*Metric tons spilled per million metric tons transported (ppm)*
FSU Total	218,536	588,379	4,000	371	55

***** Taken from Penwell International Petroleum Encyclopedia 1967-1997).
Source : Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

CONCLUSIONS AND RECOMMENDATIONS ON SPILL RISK ASSESSMENT

6.35 Within the FSU states, Azerbaijan appears to have the highest failure rate, whereas Belarus and Kazakhstan appear to have the lowest. Except for Russia the number of oil spills in each country of the FSU is small; thus these conclusions are uncertain. Failure rates for the six Russian regions defined in this study may be higher in Russia North and East and lower in Russia West.

6.36 The variation in failure rate between the non-Russian FSU countries can be due to various factors such as the following:

?? differences in the ages of pipelines;

?? differences in environmental, climatic, geological and soil conditions and their effects on pipelines and pipeline routing: ,

?? differences in construction standards;

?? differences in implementation of contingency plans; and

?? differences in reporting thresholds for oil spill events.

6.37 It is recommended that these factors be further studied in the next phase of the study in order to be more specific about their effects on oil spillage and pipeline failure rates.

6.38 Based on the analysis in this study, the following conclusions may be drawn:

?? There may be more mechanical failures and operational errors in FSU than in Western Europe.

?? The age of the pipeline could be an important factor in the rate of pipeline failures; and this factor could account for the different failure rates of FSU countries.

?? The volume of oil spilled is higher in FSU than in Western Europe. The reason could be poor contingency planning, poor detection (partly due to the large, sparsely-inhabited areas in the FSU), longer distance between emergency shutdown valves, or larger-than-average dimensions of pipelines in the FSU. All these factors should be further analyzed in the next phase of the project.

B. Environmental Risk Assessment

GENERAL CONSIDERATIONS

6.39 This study assessed the environmental risk of oil pollution from crude oil pipelines in the FSU, based on available oil spill information gathered during this study. This information is inadequate for detailed impact assessments of the spills for the environment and population .

6.40 Environmental risk is a combination of probable and actual environmental damage. Impact severity, including biological effects and impact on ecosystems, may be assessed by using the following factors:

- ?? the spreading potential of the oil (releases to streams, rivers, and canals are considered to have the highest spreading potential);
- ?? oil properties, which change over time;
- ?? oil quantity; and
- ?? sensitivity to oil pollution (that is, the short- and long-term vulnerability of habitats and species populations).

6.41 Earlier investigations and assessments (Clark 1984; Dunnet et al. 1990; GESAMP 1980) on the environmental impact of human activities conclude that human-induced mortality is significant only when it has some impact on species populations. The long-term effects and the recovery time depend on the size, distribution, and other population dynamics of the species in question. Species with low clutch sizes and a long pre-reproductive stage generally have a slow recovery rate from oil pollution.

DISPERSION CHARACTERISTICS OF OIL IN DIFFERENT ECOSYSTEMS

6.42 Adverse biological effects of oil spills in terrestrial environments are principally a function of the extent of oil dispersion, which again depends on the prevailing environmental conditions.

6.43 Depending on the soil properties in the area of the spill, an oil spill may do the following:

- ?? disperse in rivers or streams;
- ?? aggregate in ponds;
- ?? evaporate;
- ?? penetrate into the ground;
- ?? be retained in the ground;
- ?? be degraded by microbial activity;
- ?? cause groundwater contamination; or
- ?? sink beneath groundwater level.

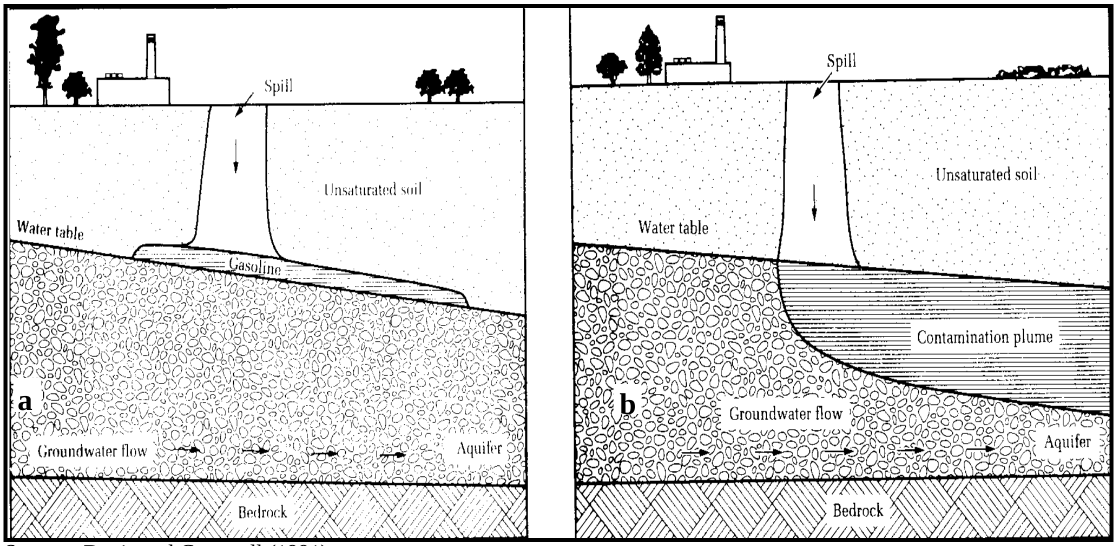
6.44 The above factors will all influence the dispersion characteristics and environmental effect of an oil spill.

6.45 Leaking oil may pass through several different hydrological zones as it migrates through the soil. In the capillary zone of the soil, just above the saturated zone that marks the groundwater table, spaces between soil particles may be saturated by water rising from the water table by capillary action. Chemicals lighter than water, such as most refinery products and crude, will "float" on top of the water table in this zone, and move in different directions and rates than the water-soluble fractions (Figure 6.10).

Figure 6.10 Spilled Refinery Products in Hydrological Zones

A) Immiscible plume of hydrocarbon fractions less dense than water

B) Dissolved contamination plume



Source: Davis and Cornwell (1991).

6.46 Below the water table, all pore spaces between soil particles are saturated. Generally, the saturated zone is devoid of oxygen. If oil penetrates this zone, the lack of oxygen will limit the oxidation and degradation processes.

6.47 The water-soluble fraction (WSF) will follow the groundwater and form a distinct plume (Figure 6.10). The shape and size of the plume depends upon the local hydrogeological conditions, groundwater flow, the characteristics of the oil, and geochemistry.

VULNERABILITY OF ECOLOGICAL COMPONENTS

6.48 Ecosystem vulnerability changes with its complexity; the less complex the ecosystem, the greater the potential for long-term effects. Less complex systems such as the Arctic generally have fewer species and less structural variation. Few species lead to shorter food chains and damage to any one link adversely affects many of the other links. A general description of the vulnerability of some important ecological components is given in the following text.

Potable water

6.49 Dissolved toxic components of oil may contaminate water used for drinking or irrigation of arable land . Pumping stations and equipment may also be affected. Small concentrations of oil in water may also cause tainting of the water or farming products.

Wetlands and rivers

6.50 The effect of an oil spill is greater when it occurs in wetland (marsh, drainage ditches, and river) areas than when it occurs on agricultural land. Within a wetland, the water level at the time of a spill can greatly affect the distribution of oil, with large areas at risk during flooding since oil can spread quickly over water surfaces. At times of low water level however, water drains down through the substratum and only relatively small areas may be affected, but with enhanced penetration of the substratum. This in turn may lead to longer residence times and difficult cleanup jobs. The oil may be carried up the stems and leaves of wetland vegetation by water table movements (Baker 1969; Baker et al. 1989).

6.51 With respect to oil spills, Baca et al. (1985) distinguish between standing water wetlands and rivers as presented in Table 6.6.

Table 6.6. Characteristics of Oil Spills in Standing Water Wetlands and Rivers

Standing water wetland	*Rivers*
Long residence time of oil	Short residence time of oil
Interior oiling and pooling	Fringe vegetation oiling
Slow recovery rate	Rapid recovery rate
Difficulty of access	Accessible
Relatively difficult to clean	Effective natural cleaning due to currents

Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

6.52 Many wetland ecosystems, such as swamps and marshes, are dominated by robust, productive perennial plants with substantial underground systems (Johnson and Hoskens 1952). The time of year that oiling occurs can affect the recovery of such plants. If emergent shoots are subject to oil pollution during the period of rapid growth (spring and early summer), regrowth is rapid after cutting to remove oiled vegetation. However, if oiled vegetation is cut after the emergence period, then cut shoots are hardly replaced, underground autumn reserves are reduced, and growth for the next year is reduced.

6.53 With respect to marshes, oiled salt marshes are the closest with respect to marshes, oiled salt marshes most resemble a definable ecological area for which the effect of oil spills has been studied for which oil spill information is available. They can take 20 years or more to recover naturally depending on circumstances. Recovery of perennials from thin films of crude oil is usually rapid, but thick smothering oil layers can kill the vegetation. One oiling, even if it is relatively thin, typically kills annuals. Mosses are known to be very sensitive to oil pollution. Experiments in Canada showed that mosses, lichens, and liverworts were eliminated after an oil spill and had very little recovery after three years (Hutchinson and Freedman 1975).

6.54 The free-floating vegetation of rivers and canals is thought to be particularly vulnerable to oil because it lives at the air-water interface where most spilled oil is initially distributed. Furthermore, this vegetation has no protected underground reserves from which regeneration could take place. On riverbanks, plants oiled during a flood can be susceptible especially if the flood rapidly subsides, allowing oil to penetrate riverbank sediments and to contact root systems. Small plants, particularly annuals, are likely to be most damaged because they also lack the underground reserves, which would help in regeneration.

Impacts on vegetation

6.55 In general, perennial species with well-developed root systems tend to be robust and able to recover from oiling incidents, whereas annual species are not as resistant because they do not have the reserves underground to send up new growth. The time of the year when pollution occurs also affects the level of impact. Perennial species are more sensitive in the pre-seeding period as compared to the autumn period of seed maturation.

6.56 Severe oiling heavy penetration of the soil can kill trees by affecting the root systems, although a more commonly reported effect is temporary stress (as evidenced by leaf drop) followed by recovery within a year. However, if the soil is very wet or flooded this probably gives some protection to tree root systems.

Tundra areas

6.57 The tundra environments are particularly susceptible to disturbance, and effects remain visible for many years. Many of the Arctic plants are very sensitive to oil, especially lichens, which are the main food of reindeer. Disturbance to the thin layer of vegetation covering a frozen soil can precipitate a dramatic melting of the underlying ice and result in extensive erosion.

6.58 The combined effects of the frozen ground, acting as a barrier to oil, and the waterway systems, facilitating vertical transport, were observed in the Komi incident. Several thousand metric tons of oil were spilled on the tundra, and the Kolva, Khatayanka, and Usa rivers (all tributaries to the Pechora River) were fouled by the pipeline rupture spill (Kolstad and Hansen 1994; Sagers 1994; United Nations 1994c).

6.59 Arctic freshwater systems are poorly buffered and therefore vulnerable to pollutants. The small lakes in the terrestrial Arctic systems are among the most vulnerable areas (Atlas 1985; Dunbar 1985).

Fish resources

6.60 The youngest stages of organisms (such as fish eggs and larvae) are generally accepted as being the most susceptible to oil pollution (GESAMP 1993). Later developmental stages (that is, juvenile and adult fish) tend to be more resistant and less vulnerable to oil pollution. Adult fish are able to detect and tend to escape from oil-contaminated water even at very low oil concentrations (Boehle 1986).

Seabirds and waterfowl

6.61 The vulnerability of birds to oil may be related to species-specific biological attributes such as the following (Anker-Nilssen 1987; Leighton et al. 1985; Tasker et al. 1987).

- ?? Behavior: Several species (during molting, reproduction and migration) tend to aggregate for periods in dense populations within limited geographical areas. During such periods even small spills may affect a large number of animals.
- ?? Season: Wintering and migrating species aggregate and spend most of their time at sea. The temperature is generally low in winter, and longer periods of darkness may reduce their ability to recognize oil spills. During the molting period in autumn, ducks and auks lose vital feathers from the wings, making them unable to fly. During these periods, the birds spend their time at sea, often in aggregated flocks.

?? Feeding behavior: Species mainly feeding at or beneath the sea surface (pelagic species) should be regarded as relatively more vulnerable. Auks, marine ducks, divers, and cormorants are examples of such species.

?? Reproduction: Most true seabirds are k-strategic, that is, having a rather long life span but with low reproductive rates. If oil spill damage is severe, with loss of a significant part of the population, the recovery period may last for decades.

6.62 When oil spills have a severe impact on the reproductive part of the population, a species may take decades to recover.

6.63 Evidence of correlation between amount of damage and amount of oil has not been established for seabirds; even small spills may cause heavy mortality. The reason for this is assumed to be the significant fluctuations in the temporal and spatial distribution of animals, and species-specific feeding, behavior, and reproductive patterns.

ENVIRONMENTAL RISK IN THE FSU

6.64 Thirty-four of the 113 oil spill incidents in the FSU were reported to have polluted rivers (Table 6.7 but only few of the reports included information about environmental damage, and therefore the number of environmentally harmful incidents may be underreported (Clark et al. 1996). Oil from pipeline accidents flows along the lowest terrain, which is generally dominated by wetland and aquatic systems. The oil issuing from a buried pipeline will initially spread by gravity below the surface, but it will eventually reach the surface, depending on the porosity of the soil and the position of the water or permafrost table (Zoltai and Kershaw 1994). The surface flow of the oil will follow natural drainage ways and may eventually reach streams and rivers. Once oil has reached flowing water it is transported and dispersed to larger areas and has the potential to cause more extensive damage. Oil spills reaching streams and rivers will therefore have a severe impact on the environmental.

Table 6.7 Effects of Oil Spills from Pipelines in FSU Compared to Western Europe

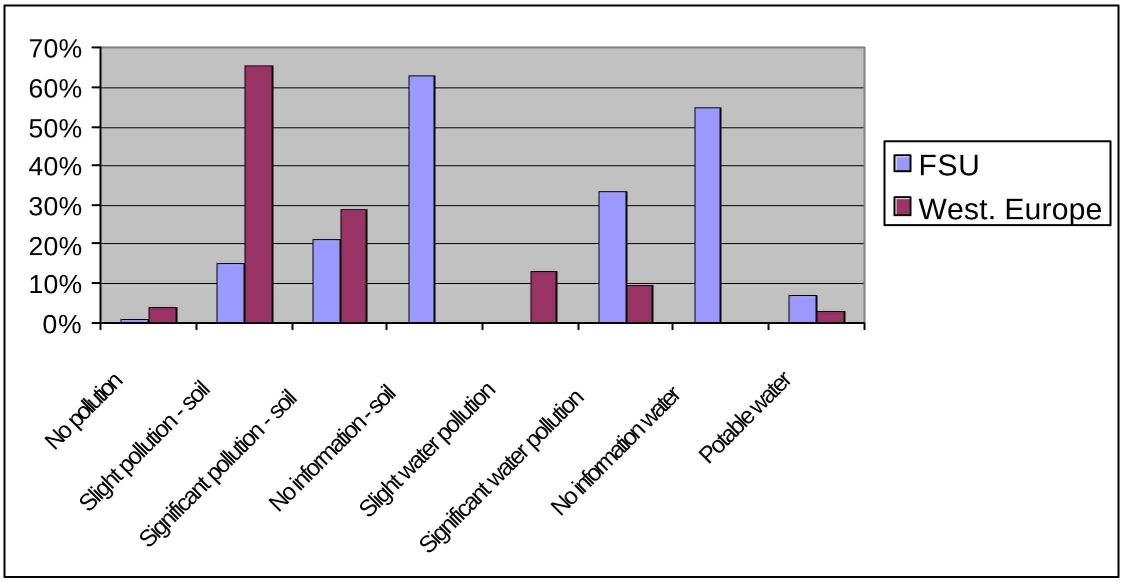
	1986	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*Sum FSU 1986–96*	*West. Europe 1986–96*
Number of incidents	1	3	4	8	21	19	28	29	113	124
Pollution resulting										
No information				—	1	—	—	—	1	5
Soil										
Slight	—	1	—	—	1	3	6	6	17	81
Significant	—	1	—	2	5	3	6	7	24	36
No information	1	1	4	6	14	13	16	16	71	0
Water courses										
Slight				—	—	—	—	—	—	16
Significant	1	1	4	5	6	3	7	11	38	12
No information		1		3	11	16	19	12	62	0
Potable water	—	—	1	1	1	2	2	1	8	4

— = Not available.

Source: CONCAWE. Spillages from Oil Industry Cross-Country Pipelines in Western Europe

6.65 As shown in Figure 6.11, the number of reported incidents in FSU is comparable to Western Europe, but a number of the incidents that reportedly had no pollution effect on soil or water may actually have experienced such consequences (see Table 6.7 and Figure 6.11). Sixty percent of the reported incidents in the FSU include no information about soil pollution, whereas all spills in Western Europe had soil pollution reports. Considering only the 42 incidents with information about effects on the soil, 57% of these spills resulted in significant pollution compared to 26% in Western Europe. Likewise, 75% of the total 51 incidents with information about water pollution resulted in significant pollution compared to 10% in Western Europe. These numbers indicate that only severe oil pollution incidents are included in our information.

Figure 6.11 Percentage of Total Reported Oil Spill Incidents in FSU and Western Europe, 1986–96, Distributed on Consequence Categories



Source: Pipeline Oil Spill Prevention and Remediation in FSU, DNV, 1997.

6.66 Soil properties in the permafrost areas will probably lead to increased dispersion of oil and increase the probability of water pollution. More than 7,000 pipeline kilometers (9% of total FSU) are located in permafrost areas. Nineteen of the reported incidents (17%) occurred in these areas: one in an area characterized by discontinuous permafrost (50%–90 % of the area), seven in areas with sporadic permafrost (10–50%), and eleven in areas with isolate (less than 10%) of permafrost areas. These figures indicate a somewhat higher probability for oil pollution in permafrost regions.

6.67 Only five of these spills (26%) were reported to pollute rivers, lakes, or potable water, compared to 34% of total reported incidents. Eleven were reported to result in soil pollution (58% compared to 36% of total), but most of them (seven incidents) were reported to result in only slight soil pollution. This supports the suspicion that the number of environmentally harmful incidents may be underreported.

CONCLUSIONS ON THE ASSESSMENT OF ENVIRONMENTAL RISK IN THE FSU

6.68 The data indicate that there is a higher frequency of oil spills in the permafrost areas, but that these incidents have lower consequences compared to the general picture from FSU. These figures result in a lower than expected environmental risk in the permafrost areas.

6.69 The data indicate a higher environmental risk in the FSU than in Western Europe, with both higher frequency of spills and more serious consequences.

6.70 Detailed environmental risk assessments for oil pipelines in the FSU will necessarily concentrate on one or two areas where detailed information may be compiled directly from local authorities, pipeline operators, and local scientific institutions.

7

General Conclusion and Recommendations

7.1 The following are the main conclusions and recommendations from this study.

(a) Among the FSU countries, Azerbaijan with 0.8% of total pipeline kilometers had the highest pipeline failure rate during the period of the analysis. Belarus and Kazakhstan had the lowest failure rates, with 3.4% and 9.8% of total pipeline kilometers respectively. These variations could be due to a number of factors, including the following:

?? differences in the ages of pipelines;

?? differences in environmental, climatic, geological, and soil conditions and their effects on pipelines and pipeline routing: ,

?? differences in construction standards;

?? differences in implementation of contingency plans; and

?? differences in reporting thresholds for oil spill events.

These factors should be reviewed in greater detail so as to establish more precisely the parameters that would explain the differences in failure rate.

(b) Except for Russia, the number of oil spills in each country of the FSU is small when compared to the volume of oil transported. However, this conclusion is based on the limited data set used.

(c) Comparing the six geographical subdivisions of Russia as used in this report, Russia North and Russia East, which are located in the tundra climatic region, have higher pipeline failure rates (at 0.6 and 0.5 per 1,000 km–years respectively) as compared to Russia West with pipeline rupture rate of about 0.15 per 1,000 km–years, highlighting the fact that the pipelines in the tundra region are more susceptible to ruptures than in the other climatic regions.

(d) Failures due to third-party activities are significant in both the FSU and Western Europe, thereby highlighting the need for establishing an effective regulatory and monitoring mechanism for oil pipeline operation in countries.

(e) On the basis of the limited data set used, there may be more mechanical failures and operational errors in FSU than in Western Europe. This could be due to the utilization of poor-quality pipeline materials, poor construction standards, poor supervision, lack of clarity of responsibilities in the legislative and regulatory framework, or a reflection of the fact that the Russian pipelines used in this study are older in age than in Western Europe.

(f) The specific ages of the pipelines in which the ruptures occurred were not available, and hence, it was not possible to clearly establish the statistical significance of this parameter as a cause of pipeline rupture. Pipeline age does make sense as an important parameter for failure rates. The failure rate of pipelines usually follows a bathtub curve. At the start and the end of the lifetime, failure rates are high; in the middle of the lifetime failure rates are usually low. This could be due to "teething" troubles for new pipelines and due to wear-and-tear as the pipeline gets old. This effect could explain some of the differences in failure rates between the FSU and Russia. In most countries of the FSU, pipelines are relatively young. In Russia, however, most pipelines were put in operation in the 1960s and 1970s, and by the year 2000 about 73% of Russia's pipelines will be older than 20 years. In this regard, it is recommended that the age of pipelines should be studied and correlated with the frequency of spill occurrence.

(g) The severity of spillage, measured by the amount of oil spilled, is higher in the FSU than in Western Europe. The reason could be poor contingency planning for rapid response to spills; poor detection procedures; long distances between emergency shutdown valves; or the larger average diameter of pipelines in FSU. All these factors are relevant and should be analyzed better in the next phase of the project.

(h) The regulatory and monitoring systems of FSU systems are more fragmented than those of Canada, and as a result are considered not as effective in providing quick response to oil spills. There are many organizations involved in the FSU system and the level of accountability for responding to spills is poor. The Canadian regulatory system is considered more suitable for regulating pipeline operations in developing countries than the FSU system, provided that the Canadian system is appropriately modified to reflect the local laws and regulations.

(i) With regard to strengthening the regulatory and monitoring regimes of the FSU, the following measures are recommended:

?? The general fragmentation of both the legal and institutional frameworks of the Russian Federation should be further reviewed. The current fragmented nature of the frameworks probably makes coordination between the different federal bodies and agencies difficult, and also makes the regulatory responsibilities of the different agencies involved unclear.

?? The pipeline operating procedures, standards, and norms are old and should be updated. In particular, standards and norms (also the industry norms) should be updated to meet the new Onshore Pipelines Regulations and the CSA pipeline standards.

?? The FSU legal and regulatory frameworks are considered by the pipeline operators and owners to focus more on punishing offenders than on providing guidance for efficient and safe operation of the pipelines, and this creates an unwillingness by the pipeline operators to report spill occurrences. The focus of these frameworks should be changed to encourage a more preventative approach that emphasizes institutional awarene ss of the environmental impact of oil spills.

(j) The data gathered in this study show that mechanical failures and operational errors are the main causes of pipeline failures in the FSU (at 42% and 10% respectively), compared to 26% and 5% respectively in Western Europe. Attempts should be made to reduce the effects of these factors through better monitoring of the pipeline operations.

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