PROVINCE OF MANITOBA
THE CLEAN ENVIRONMENT COMMISSION

Report on The Investigation of the Pollution of Underground Water by Refined Petroleum Products

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Contamination of Underground Water Sources by Refined Petroleum Products

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Chapter 1

INTRODUCTION

Pollution of groundwater by refined petroleum products is not a new problem in Manitoba. Several cases, some attributed to spills and others to leaking tanks, have been investigated in the last twenty to thirty years by provincial public health inspectors. In recent years, however, the number of reported cases appears to have increased considerably.

In some instances a fire hazard was created by gasoline fumes which accumulated in the basement of dwellings; in recent years this occurred in Flin Flon, where houses had to be evacuated. In most cases the complaints were about domestic water supplies that had become unfit for use.

The increased frequency of the problem made an investigation desirable, especially because this form of environmental contamination has several disturbing features.

Firstly, drinking water becomes unpalatable even when it contains petroleum product in extremely low concentrations; relatively small spills may thus impair large bodies of groundwater. Secondly, contaminated aquifers cannot be cleaned up adequately by any proven technique [1] and natural dispersion or break-down is extremely slow; a contaminated water supply may thus remain unusable for many decades. Thirdly, it is often

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1). Recent work on bacterial decomposition holds out the promise of a substantial improvement of clean-up techniques; it appears, however, that much research needs yet to be done in this field.

difficult to pinpoint the source of the contamination with sufficient certainty to determine legal responsibility. And, fourthly, Manitoba has presently no legislation that is aimed at preventing this form of contamination by regulating the handling of product or by setting design and installation standards for underground tanks.

The Clean Environment Commission therefore concluded that it was desirable to investigate the problem in its entirety and decided to hold public hearings that would form the focal point of the investigation.

Two public hearings were held; the first in Winnipeg on November 18 and 19, 1974, and the second one in Bird's Hill, Manitoba, on March 17, 1975. To the first hearing the Commission invited spokesmen for the industry, personnel from various levels of government within and from outside the province, as well as the general public. All were asked to assist the Commission in obtaining a clear understanding of the problem and to suggest ways and means of coping with it. The hearing in Bird's Hill focussed on local experience and on specific local concerns. A limited number of transcripts of these hearings are available from the Commission's office.

The Commission also wrote to many agencies in Canada and the United States for information and informed opinion on the subject. An extensive documentation of the many aspects of this problem was thus obtained.

The whole investigation was aimed at enabling the Commission to make specific recommendations to the Government about legislation dealing with the problem. Since the Commission is not a technical body, it decided to invite comments from the industry and from interested and experienced government agencies on specific issues prior to making definite recommendations. For this reason a preliminary report was issued with tentative conclusions which was given a wide distribution. The results were very gratifying. Many agencies, both in the public and the private sector, went out of their way to provide the Commission with valuable comments and suggestions. These were found quite helpful in formulating the summary and conclusions which, in revised form, are contained in the last chapter of this report.

The investigation was limited to contamination by refined petroleum products, such as: gasoline, jet fuel, domestic and industrial heating oil, diesel fuel, lubricating oil and solvents. The Commission is well aware of the environmental hazards associated with the production and transportation of crude oil but considered this outside the scope of the study.

Chapter 2

DESCRIPTION OF THE PROBLEM

Nature of the Contamination

Various environmental hazards may arise from leaks or spills of petroleum product. Combustible vapours may collect in sewers or basements of buildings and create a fire hazard. Or, a film may form on surface waters which is toxic to some forms of plant and animal life and which may interfere with recreational use. Petroleum product may contaminate wells and make the water undrinkable. Or, it may contaminate the soil itself by coating the soil particles with an oil film which is difficult to dislodge and which over a long period of time releases soluble pollutants that are carried by percolating rainwater to aquifers tapped by domestic wells.

The seriousness of the contamination depends on the mobility of the oil in the ground and, to a lesser degree, on the solubility of its components. There are large differences both in mobility and solubility; this explains why some spills have caused serious trouble and many others not.

Concerning the solubility, the heavier fractions have less, the lighter ones have more soluble components. From the point of view of groundwater contamination the distinction is probably of minor importance since even minute quantities of dissolved product will make the water unfit for human consumption.

The mobility of petroleum products in the soil depends mostly on three factors. The first is the viscosity of the oil;

heavy oils do not readily penetrate the soil while lighter fractions, such as gasoline, move through soil even more easily than water does. The second factor affecting mobility is the quantity of product that is released. Oil leaves a coating on the soil particles as it traverses successive layers; therefore, the amount of oil that travels on is gradually reduced until movement virtually stops. It follows that large spills travel farther than small ones. The third and most important factor is the permeability of the soil. Spilled product may move readily through sand and gravel layers while clay may prove an effective barrier. Some bedrock is also very permeable because of fissures and cracks, in particular sandstone and limestone, while other formations are quite tight.

It should be noted that sand and gravel layers as well as the fissured bedrock strata constitute the most productive aquifers for domestic wells and that the shallower layers are the most accessible. The relative permeability of the upper strata is therefore the most important single factor that determines the vulnerability of a locality to contamination of domestic water supplies.

The oil spill itself need not reach the groundwater table to contaminate it. Shallow groundwater bodies are constantly replenished by rain and melting snow which percolates through the soil. When passing through contaminated layers the water will pick up the soluble components and carry them along.

If the spill is large enough to reach the groundwater table, then the oil is forced to spread laterally; it cannot penetrate the groundwater since oil is lighter than water. Assisted by the groundwater flow, the oil then spreads out in the form of a thin pancake. Soluble components will dissolve in the water and vapours will be released.

Hazards Caused by the Contamination

Several instances of fire hazards caused by spills or leaks of combustible liquids into the ground have been reported in the province. In Flin Flon the Medical Officer of Health had to order a number of families to evacuate their houses because gasoline fumes from contaminated groundwater kept accumulating in their basements.

Fortunately, gasoline vapour is readily detected by smell at concentrations much below the explosion hazard level. Explosions can thus be prevented in practically all cases by taking reasonable precautions. But the hazardous condition may last for a long time during which a building may remain unfit for occupancy.

Little is known about what causes gasoline vapours to accumulate in any particular location. In this connection the formation of a so-called frost shield in the ground has been mentioned; this could perhaps cause vapours to travel laterally to points where their accumulation would be dangerous.

Most complaints arise from the pollution of domestic wells. The human taste is very sensitive to petroleum and a concentration of 0.5 lbs in 100,000 gallons of water will be obnoxious to most people. Some individuals taste petroleum in concentrations as low as 0.005 lbs in 100,000 gallons.

The acute hazard to health arising from the consumption of contaminated water is reported to be low because it becomes undrinkable at contamination levels far below the toxic level. But the Commission has received medical opinion expressing concern about the possible long-term health hazards caused by the ingestion of trace amounts and by the inhalation of vapour. No concrete evidence has been produced but the overall effect on health remains an open question.

Sources of Contamination

Three main sources of contamination will be discussed in this report: spills during transfer of product, the dumping of waste oil and leakage from underground storage tanks and their piping systems. The catastrophic spills caused by major pipe line ruptures, by highway or railway accidents involving the transport of oil or by the shipwreck of tankers, are outside the scope of this study.

Human error is by far the most important factor in spills during transfer of product. The error may take the form of inattention, of failure to check the capacity of the tanks to hold the estimated amount, of opening the wrong valve, of making the wrong connections, etc. The root cause may be carelessness or inadequate training. It is important to note that, while errors are bound to occur, the continued presence of an operator at the controls is the best way of minimizing their ill-effects.

The dumping of waste crankcase oil in a convenient ditch has been a common practice in the past and is likely to continue as a source of groundwater pollution until the re-use of waste oil becomes the accepted method of disposal. This may require government intervention in the form of regulations or incentives aimed at providing suitable collection, storage and recycling facilities. At the hearings the important point was made that quarries and gravel pits are especially vulnerable to infiltration by spilled oil; it was also pointed out that quarrying and gravel processing are operations that require heavy machinery which needs frequent oil changes.

Leakage of storage tank and piping systems is a major source of contamination. Statistics collected in Ontario over a four-year period show that leaking tank and fuel lines were responsible for about two thirds of the pollution problems reported; the remainder was attributed to spills or to miscellaneous and unknown causes. Loss sizes varied from 150 gallons to 11,000 gallons and sixty percent of the reported cases involved gasoline as opposed to diesel fuel.

Additional information from the American Petroleum Institute shows that with tank and piping systems 61.1% of the leaks stems from the underground piping, 21.6% is from the underground tanks, 3% occurs in the dispenser, 3.3% in the flexible hose connector and 6% is from other sources.

Trouble with piping probably reflects poor installation practice rather than corrosion. It is important to note that at present there is no legislation in the province dealing with the installation; the occurrence of inadequate installation practices is therefore not surprising. Moreover, in many locations the soil is compressible and subject to seasonal movement which may cause joints to start leaking.

Few, if any, of the underground tanks presently in use in the province have cathodic protection, many have coatings that are considered to be inadequate by present day standards, and then, these may well have become damaged during the installation. The average life of such tanks has been estimated to be 12 to 15 years under favourable conditions. In corrosive soils, such as do occur in many parts of the province, the useful life of the tanks may be only a fraction of the average. The occurrence of leaks is therefore only a matter of time.

Leaks may develop gradually and may remain unnoticed till the losses become economically significant for the operator. By then a large aquifer may have become contaminated.

Local Incidence of the Problem

Contamination of groundwater supplies by petroleum products has been reported in all Canadian provinces, in the United States of America and in Europe. The available documentation suggests that it occurs wherever petroleum products are used on a large scale. In Manitoba the problem appears to be as bad as anywhere in Canada.

To date groundwater contamination has been reported in 36 separate communities in the province. The source is not always known. Some instances may have resulted from careless handling of gasoline by the property owner himself in the vicinity of his well. Accidental spills and dumping of waste oil may account for several other reported cases. But there are indications that in a substantial number of problems leaking underground storage tank systems have been to blame.

Underground storage tanks for gasoline and for diesel fuel are found in every hamlet and along all major highways; in addition there are countless underground tanks for industrial and farm use and for the storage of heating fuel. Many of these tanks have been in the ground for a long time and, considering what they are made of, one must expect leaking tanks to be a rather common occurrence.

In many locations thick impervious clay layers separate the fuel tanks from any usable aquifer; the loss of product may then be the only ill-effect that can be observed. If, on the other hand, the tank is located in a pervious layer which is connected to a used aquifer, then the first sign of trouble may be the pollution of a domestic well. Even in productive aquifers the movement of water and any contaminants is very slow. Contamination may therefore show up long after the leak or the spill has occurred and there is the possibility that the reported cases of pollution form only the visible tip of the iceberg.

Remedial Action After Contamination has Occurred

Large surface spills, if discovered in time, can be recovered in part. The problem of maximum recovery, while of obvious importance for the problem at hand, has received considerable attention from the side of the industry as well as from the governments, so that it need not be discussed here. Instead the question will be asked what can be done for the householder, whose basement fills up with fumes and whose well yields water that smells and tastes of gasoline.

In general the clean-up of a contaminated aquifer is not possible. Following a large leak or a spill, some product may be recovered; indeed, every attempt should be made to recover as much as possible, if only to limit the areal extent of the contamination. Nevertheless, in most cases enough oil will remain in the soil as a film adhering to particles or as free oil, to contaminate well water for many years.

Two natural processes tend to remove the contaminants; they are bacterial break-down and dispersion. But both are extremely slow, if operative at all. In the aerated zone of the soil, bacteria will break petroleum down; at greater depth, where conditions are not favourable for the bacteria, petroleum persists indefinitely. Research is presently under way to improve bacterial break-down and while the results to date appear to be promising much work remains to be done. The second natural process, dispersion, is caused by the flow of groundwater, which will eventually remove the oil from the area. But the flow of groundwater is usually measured in inches per day, even in the most productive aquifers, so that the dispersion is a very slow process.

One may safely conclude that contamination at any location is likely to persist for decades. Experience bears this out. A small spill, which occurred in one Manitoba community six years ago, still contaminates nearby domestic wells. Examples from outside the province have been quoted of contamination cases which persist after 20 and 70 years.

The contamination of wells may not remain constant though. Groundwater levels are subject to change. When the water table rises hydrocarbons may be picked up from the oil film on soil particles, when the groundwater level goes down the supply of pollutants may be less. By the same token, the contamination may in time spread to wells that were previously free from it and it all may take years because of the slowness of groundwater movement.

If the contamination is not too severe then the water supply can be made usable by means of activated carbon filters. Such filters may have to be replaced frequently. In addition, they drastically reduce the rate of flow. In other instances it is better to install a new well. When the contamination is extensive then it may be best to install a municipal water system. With a municipal system the hydrocarbons can be removed by aeration.

The great variability in soil and water conditions may make it possible to find solutions to the problem of contamination in isolated instances. On the whole, however, the best way of dealing with the problem lies in prevention.

Chapter 3

CURRENT REGULATORY CONTROL

Current Legislation

The Provinces British Columbia, Alberta, Saskatchewan, Ontario and Quebec and the Northwest Territories have legislation concerning the safe handling practice of petroleum products and the construction and installation of underground storage tanks. British Columbia has Regulations pursuant to the Fire Marshall's Act "Governing the Manufacture, Sale, Storage, Carriage, and Disposal of Inflammable Liquids and Oils". In Alberta the legislation is contained in the "Service Stations and Garage Regulations" made pursuant to the Fire Prevention Act. Saskatchewan has "Regulations under the Fire Prevention Act Governing the Storage and Handling of Inflammable Liquids". In Ontario the legislation is laid down in the Gasoline Handling Code, which is a Regulation under the Gasoline Handling Act. Quebec has the Petroleum Products Trade Act. In the Northwest Territories the pertinent legislation is "An Ordinance Governing the Storage, Transportation and Distribution of Inflammable Petroleum Products".

The older regulations are rather minimal. The Alberta regulation, for example, makes both the tank truck operator and the service station operator responsible for taking all due precautions before a cargo is discharged. The tank truck operator must remain within 20 feet from the truck and must maintain constant supervision during the entire discharge operation so that none of the gasoline overflows the tank into which it is discharged. To protect underground tanks against corrosion, the regulation specifies merely a coat of red lead paint followed by one coat of asphalt paint or coal tar paint, to the satisfaction of the inspector.

The Ontario and Quebec legislation, being much more recent, is more specific and more stringent. The Ontario legislation requires the truck operator to gauge the tank in which he is to discharge the gasoline to ensure that it will hold the volume he intends to unload. The operator is not allowed to remain in his vehicle while unloading, but must remain in close proximity of the discharge control. Similarly during loading, he must maintain a position that will permit him to shut off the flow of product instantly. In the event of spillage he is obliged to take immediate corrective action and to notify the nearest inspector forthwith. The Quebec legislation has very similar clauses governing the transfer of product.

With regard to the protection of underground tanks against corrosion, the Ontario regulation requires that all tanks installed after May 1st, 1974, be in accordance with the now current Underwriters' Laboratories of Canada Standard for Protected Steel Underground Tanks, ULC-S603.1-1973. This standard specifies a high grade protective coating in addition to cathodic protection. The Quebec legislation does not make cathodic protection mandatory.

Manitoba has no legislation which specifically deals with these matters. Municipal governments may have written into their bylaws the requirement of complying with the National fire Code of Canada. The present Code, however, is far from adequate and is presently being reviewed. It appears that the new edition, which will contain as part 4 a section entitled: "Flammable and Combustible Liquids" will provide many desirable requirements also from the point of view of environmental protection. It must of course be incorporated in municipal or provincial legislation to become law.

The Clean Environment Act forbids the contamination of soil or water in excess of prescribed limits. But since no limits have been prescribed under the Act, having a leaking tank, or causing a spill is no offense. It is true that the Act may be used to require a person responsible for the spill or leak to clean up at his own expense; this, however, is hardly a practical method of dealing with the overall problem. A regulation dealing with the handling and storage of petroleum product is clearly needed. In view of the grave environmental consequences of this form of contamination, it would seem that the Clean Environment Act would be the logical base for such a regulation. Encorporating the new National Fire Code in the regulation would at the same time serve the interest of fire protection.

Industrial Policies

The absence of pertinent legislation in Manitoba does not necessarily mean that current practice in this province is entirely without control. It is in the interest of the petroleum industry itself to avoid leaks and spills; therefore the industry has developed its own policies and guidelines aimed at preventing them.

Spokesmen for the industry stated at the hearings that it is the policy of the industry to adopt the most recent standards for the design and installation of underground tanks and their piping systems; this is the aforementioned Underwriters' Laboratories of Canada Standard ULC S603.1-1973.

Company policy, however, cannot be considered at par with enforceable legislation. In addition, besides the major companies there are others, commonly referred to as the independents, who may or may not follow the same policy. Furthermore, the ULC standard referred to is primarily concerned with the design and manufacture of the tanks. Although it contains some rules concerning the installation, this as well as maintenance and leak detection is not within the normal purview of the Underwriters' Laboratories. And finally, the most pressing problem is not with the new tanks but with the multitude of old ones that were installed before the current standard was developed.

The industry has also formulated policy aimed at safe handling of the product, the prevention of spills and the detection of leakage. This is of the greatest importance and must remain the first line of defense. Legislation in this area is needed not so much to improve or add to this policy but to enforce maintaining uniformly high standards across the entire province.

Chapter 4

SUGGESTED PREVENTIVE MEASURES

Manufacture of Underground Tank and Piping Systems

The incidence of leakage can be reduced by eliminating corrosion of underground tanks. This can be achieved by the use of fibreglass reinforced plastic tanks or by cathodic protection of steel tanks. Theoretically it can also be achieved by means of a coating; however, a coating may be damaged during the installation and backfill procedures and this element of uncertainty cannot be eliminated.

Cathodic protection inhibits the electro-chemical process whereby the iron of the tank goes into solution as metallic ions and is subsequently precipitated as rust. Cathodic protection does this by setting up an electrical current between anodes that are buried in the adjacent soil and the tank, which then becomes the cathode in the circuit. The resulting electric potential opposes the movement of the iron ions and thus rusting is prevented. The required current is generated either by using sacrificial anodes which makes the system into a large electric cell, or by means of an impressed current. In either case any exposed metal is protected and the protection will continue as long as the current is maintained. Sacrificial anodes are eventually consumed but can be replaced. Their condition can readily be checked by means of a simple voltage meter.

Cathodic protection does not prevent corrosion from the inside of the tank. This corrosion is generally considered to be less of a problem than corrosion originating on the outside. Nevertheless, if the outside is protected by high-grade coatings and cathodic protection, then the useful life of the tank may very well be determined by inside corrosion. It has been reported that inside coatings are mandatory in Switzerland. The Commission has been informed that the Underwriters' Laboratories of Canada are presently investigating coatings for inside protection. The Commission is not in a position to suggest what inside coatings may be effective. Since this problem involves fewer variables than outside protection, research should lead rapidly to an effective solution.

Defective piping accounts for more than twice as many leaks as defective tanks; this problem should therefore be given full attention. It has been pointed out that many problems stem from faulty design, such as the use of dissimilar metals in a piping system which creates a galvanic couple; this is a prime source of corrosion. Sometimes a copper water line is crossed by pipelines from the tanks to the pumps; the common practice of grounding electrical services to water lines then provides the required metal connection between two kinds of metals having a galvanic potential difference that are located in a common electrolyte, namely the soil. Proper design practice should eliminate such situations.

Settlement and heave are common problems in many Manitoba soils; this may cause movement at the joints in pipes. It is necessary that all joints be designed to take some movement without starting to leak. In addition, it is desirable that all piping drains towards the tank and that pumps be of the suction type.

Proper installation practice is of the greatest importance for pipes as well as for tanks. Cathodic protection or the use of fibreglass reinforced plastic tanks does not eliminate leaks due to faulty installation and slow, constant leaks may be difficult to detect by inventory control. Inspection and testing of all new installations in accordance with rigid standards is the best way of avoiding difficulties later. It has been suggested that all excavations in which the tank and piping is to be installed be left open until an inspector has had the opportunity to check and approve the installation. This suggestion seems very worthwile.

Leak Detection for New Tanks

Cathodic protection of steel underground tanks and the use of fibreglass reinforced plastic tanks may solve the problem of tank corrosion but it will not eliminate all danger of leakage in the system. Since relatively small amounts of leakage may greatly impair an aquifer, it is imperative that all measures are taken that ensure early detection of any leak.

At present there are two accepted methods of leak detection after the tank has been installed: hydrostatic testing and inventory control. A new method, using sonic equipment, is reported to be promising but the Commission has not obtained enough information on it to include it in the discussion. An air test is normally performed after the piping is installed to check whether all joints are tight, but this is not considered to be a reliable method once the tank is backfilled.

Hydrostatic testing is normally performed only when there is a suspicion of leakage. The tank must be taken out of service and emptied of product. Normally the test takes 2 to 6 hours and is reported to cost on the average $120.-- per tank. It should be noted that these figures assume that competent and trained operators are available, which apparently is not presently the case in this province. It has been suggested that periodic testing with the Kent Moore equipment would be valuable for monitoring purposes.

For installations where withdrawals from the tanks are continuously metered, such as service stations, inventory control is an important monitoring device. Every tank is provided with a dipstick, graduated in inches which can be used to check on the volume remaining in the tank. Any water accumulating in the tank can also be determined using a special paste. Since the volume delivered to the tanks is known, the operator can check on leakage by reconciling the tank storage with what went in and came out of the tank.

There are a number of problems with inventory control. Firstly, the volume of gasoline changes with temperature. The amount is about 3 gallons per 5000 gallon tank per degree Fahrenheit change, which is quite significant. It is therefore necessary to record the temperature of the gasoline that is delivered into the tank as well as the temperature of the gasoline in the tank and to apply the necessary correction. Another problem is the inaccuracy of the dipstick measurement. These can be read to the nearest inch only. This represents an uncertainty of up to 75 gallons in a 5000 gallon tank. Other discrepancies may occur because of errors or because the meter is read at a different time than the dipstick measurement. As a result one must expect discrepancies in the reconciliation in the order of a hundred gallons per tank or more even without leakage.

Fortunately, the major errors are not accumulative but will cancel out with time. Measurement errors, for example, will not carry over and, provided correct procedures are followed, errors in temperature corrections should average out. The proper procedure is therefore to record the accumulated sum of daily discrepancies, adding surplusses and subtracting shortages. Leakage should show in the series of sums as a definite trend, while errors show up as random fluctuations. The difference between random fluctuations and a definite trend shows up immediately in a graph where the accumulated sums are daily entered. Without such a graph a trend is not easy to detect.

It should be noted that any systematic error shows up as a trend. It is therefore important that procedures for inventory control be worked out carefully and completely standardized so that all operators follow exactly the same methods. Without standardization the procedure may not only be too difficult for an untrained operator but it would also be difficult to enforce meaningful inventory control.

It is expected that with daily inventory control for each tank leaks will show up within a month, if they are small and within a much shorter time if they are large.

The Commission has received a suggestion that an air sampling well be installed in the backfill between the tank and the excavated sides. Such a well could consist of a capped 2-inch diameter P.V.C. pipe with a slotted part at the lower end which would extend above the maximum groundwater level. Any fumes released from leaking gas would collect in the pipe and could then be detected by smell or by an explosimeter. It appears that this device has been tried in Ontario and that it had to be abandoned because it was too sensitive. Minor surface spills would be indistinguishable from leaks.

It thus appears that daily inventory control is the best way of monitoring for leaks on a continuing basis. Periodic application of the hydrostatic test would likely add little to a properly conducted inventory control program. For example, assuming that with inventory control leaks are detected within a month and that hydrostatic tests are performed on a routine basis once every 24 months. The chances are then 24 to 1 that a leaking tank will be discovered by inventory control rather than by the hydrostatic test.

There is undoubtedly a great need for a simple device which can be used on a routine basis to detect leakage as soon as it occurs. At present this is not available. It is therefore important to do the best with what is available and to use the inventory control to the best advantage.

Control Over Existing Tanks

Existing tanks are the most difficult problem in any attempt to bring groundwater pollution by petroleum products under control. Several facts stand out in a review of the situation.

In the first place, all existing tanks must be considered substandard in the light of generally accepted standards of corrosion protection. Although the variability of soil conditions and variations in the installation makes it impossible to determine the condition each tank is in, one must expect that many of them will develop leaks in the next few years.

In the second place, the consequences of leakage vary greatly in the province. In some areas the existence of substandard tanks constitutes a real danger to valuable water supplies, in other areas the consequences of a leak are not very serious.

In the third place, no method is available whereby a leak is detected with certainty before the amount of product that escapes exceeds what can be tolerated in sensitive areas.

It follows that in sensitive areas substandard tanks must be replaced before they start leaking; in non-sensitive areas this is not necessary provided that inventory control can be relied upon.

It is possible to delineate the most sensitive areas simply on the basis of presently available geologic information. An immediate start with a replacement program can be made here. When substandard tanks are being replaced before they actually leak the opportunity is there to gain valuable information about their condition. This information can then be used to decide how far and how fast the program of systematic replacement should be pushed.

The drawback of a flexible approach as outlined above, is that it will give rise to the accusation of arbitrariness. The alternative, namely a uniform approach, can take two forms. The one is to wait with replacement till leaks develop. This is unacceptable in sensitive areas for it means a continuation of the present situation whereby one aquifer after another is contaminated. The other is to put a time limit on all existing tanks. This is expensive and unnecessarily restrictive in the non-sensitive areas.

As far as the rights of the owners of the tanks are concerned, it must be maintained that no one has the right to conduct his business in a way so that the likely outcome is the pollution of his neighbour's wells. The requirement of replacing a sustandard tank before it leaks is therefore not unreasonable.

Chapter 5

SUMMARY AND CONCLUSIONS

General

1. Contamination of underground water supplies by refined petroleum products has been reported in as many as 36 Manitoba communities. In recent years the incidence of this form of pollution appears to be increasing.

2. In some instances a fire hazard was caused by the accumulation of gasoline fumes in basements; in most cases, however, the complaints have been that domestic water supplies have been rendered unfit for use.

3. The immediate hazard to health arising from the consumption of contaminated water appears to be small since water becomes unpalatable when it contains product even in minute quantities. No evidence has been presented about the long term effect of consuming water that contains traces of petroleum products; however, a medical authority has expressed serious concern about the ill-effects of long term ingestion and inhalation of hydrocarbons and their additives.

4. Adequate clean-up of a contaminated aquifer is virtually impossible and the natural removal of petroleum product by dispersion and break-down is extremely slow under most circumstances. While product recovery following a spill or leak may be necessary to limit the extent of the contamination,

its ill-effects are likely to persist for many decades in many locations.

5. The use of activated carbon filters may make the water supply usable provided that the contamination is not severe. This remedy, however, gives only partial relief; in addition, it seriously reduces the rate of flow and is costly since the filters require frequent replacement.

6. Sources of groundwater contamination with petroleum products are:

(a). leaking underground storage tank and piping systems;

(b). accidental spills during storage, handling and transport;

(c). indiscriminate dumping of waste oil.

Each of these sources will be discussed briefly below.

Leaking Underground Storage Tanks

7. Underground metal tanks are subject to corrosion which in time will cause leakage. Depending on the condition of the tank and the nature of soil and groundwater, leakage may occur within a few years from the time of installation; it may also take much longer. Corrosion can only be prevented by a completely intact high-grade protective coating or by cathodic protection using sacrificial anodes or an impressed current. Cathodic protection is considered essential since any protective coating is susceptible to damage during transport or installation.

8. The Underwriters' Laboratories of Canada have only in recent years included cathodic protection, in addition to a high-grade protective coating, in their standard for underground steel fuel tanks. Few, if any, of the existing tanks in the province meet this standard so that practically all tanks must be regarded as inadequate in the light of modern requirements for corrosion protection. The occurrence of leaks is therefore only a matter of time.

9. Different areas in the province vary considerably in their susceptibility to this kind of contamination. Some areas are highly vulnerable because of the permeability of the strata in which the tanks are located and because of the use of shallow or unconfined aquifers for domestic water supplies. In other areas, the tanks and the usable aquifers are separated by thick layers of impermeable clay. The more sensitive areas can readily be delineated on the basis of available geologic information. A sensitivity mapping should therefore form the basis for determining priorities and strategy in coping with the problem. A uniform approach across the province is bound to result in unnecessarily restrictive regulation in some areas, while it may not afford adequate protection in others.

10. Leaks may be detected by inventory control and by hydrostatic testing. Other means may become available in the near future but on the basis of the presently available information it appears that inventory control is the most suitable method

of monitoring the performance of the tank and piping system on a continuous basis. Hydrostatic tests are more suitable for the purpose of verifying whether or not a suspected tank actually leaks.

11. Inventory control enables an operator to detect even a small leak at a fairly early stage provided that:

(a). dipstick measurements and meter readings are not only taken daily but also reconciled daily;

(b). discrepancies are accumulated to cancel out the inevitable measuring errors;

(c). the accumulated sum of discrepancies is entered daily on a graph; leakage will show on this graph as a definite trend.

Inventory control can only be relied upon if it is made mandatory and if the procedure is completely standardized so that both compliance and results are amenable to routine inspection. Even then, inventory control falls short of providing adequate protection for the sensitive areas since the amount of product that may escape before a leak is detected and confirmed may be much more than can be tolerated.

12. Periodic testing by means of the hydrostatic test at intervals of a year or more is neither an efficient, nor an effective means of ensuring the timely removal of leaking tanks in sensitive areas.

13. Sensitive areas can only be protected adequately against

serious contamination by replacing all substandard tanks before they start leaking. A program aimed at this should be undertaken forthwith.

14. In areas not designated as sensitive, inventory control should be regarded as the first line of defense for all existing tanks. Hydrostatic tests or other acceptable tests should be required if there is a suspicion of leakage.

15. Fibreglass reinforced plastic tanks, being essentially corrosion proof, can be regarded as an equal alternative to cathodically protected steel tanks provided they are manufactured, installed and tested in accordance with strict specifications.

16. Legislation is required:

(a). to authorize a program aimed at replacing substandard tanks in sensitive areas;

(b). to ensure that proper inventory control is practiced;

(c). to ensure that tanks are tested, and if necessary taken out of service, as soon as there is an indication of leakage;

(d). to ensure that all new tanks are manufactured and installed in accordance with the latest Underwriters' Laboratories of Canada standards;

(e). to ensure that all new installations are properly tested and inspected.

Accidental Spills

17. Spills during handling and transfer of product can be prevented only if proper operating procedures are carefully worked out in advance and rigidly adhered to. The responsible department and the industry should cooperate in the establishment of rules and guidelines concerning the handling of product. They should also cooperate in the establishment of an approved mandatory training program for all personnel which may be handling bulk product.

18. Legislation should provide that all spills be reported forthwith and make product recovery and clean-up to the satisfaction of the department mandatory. In addition, each operator of a retail outlet or a bulk plant should provide a contingency plan for each operation involving the handling of product. Such a plan should be subject to the approval of the department.

Indiscriminate Dumping of Waste Oil

19. Dumping of waste oil should be prohibited; the enforcement of the prohibition should receive priority attention in sensitive areas.

20. Industry and government should together solve the problems of collecting, storing and reclaiming used lubricating oil. If the present economic incentives for the recycling of waste

oil are insufficient, then the government should provide the necessary incentives by means of taxation and subsidies.