ontario hydro

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August 23, 1994

R. Gaghadar
Ministry of Environment and Energy
Economic Services
135 St. Clair Ave. W., 7th Floor
Toronto, Ontario
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Re. Your Request of June 30, 1994 for Ontario Hydro Information Relevant to Assessing the Implications of ACES Recommendations on a New ODWO for Tritium

Attached please find our submission on the potential impact of lowering the Ontario Drinking Water Objective (ODWO) for tritium. We have included data on tritium emissions to water from our nuclear power plants, data on the concentration of tritium at water supply plants near our nuclear stations, and information on sources of tritium emissions within our stations. Also provided is an assessment of actions and technologies that could be used to further reduce our tritium to water emissions, as well as their potential costs and feasibility for implementation. In many cases the information provided is not as detailed, complete or accurate as it could be if we were given sufficient time to do a better study. We could augment the information in parts of this submission if the MOEE requires it and requests it.

We completed our own brief analysis of the potential impact on Ontario Hydro of a lower ODWO for tritium. We concluded that there would be no economic impact if the proposed level of 7,000 Bq/l were selected. However, the economic impact of attempting to comply with the levels recommended by ACES (100 Bq/l immediately and 20 Bq/l after 5 years) was estimated to be very large, generally exceeding a billion dollars. This was the case for both the recommended 100 Bq/l and 20 Bq/l levels.

There is one variation of the ACES recommendations which appears to have no adverse economic impact on Ontario Hydro at all. This would be a level of 100 Bq/l applied as an annual average concentration. The water supply plants near Ontario Hydro stations have already met that criterion over the past 10 years. However, this is not the complete scenario which must be evaluated.

The ACES report deals with the reduction of the ODWO for tritium in isolation , i.e. exposures from other radionuclides have not been taken into account. It should be noted that exposure to tritium in

water is one of the lowest dose impacts from all radioactive emissions from Ontario Hydro nuclear plants. ACES have proposed a new methodology be adopted for regulating radionuclides. They have proposed that guidelines for each radionuclide in each medium separately be based on a very low acceptable risk level of between 1 and 5 in a million. If the ACES recommendations were accepted, then this methodology and risk basis would have to be applied to other radionuclides in order to maintain a consistent rationale for the protection of public health. We have applied this methodology to other radionuclides and in other media, and have concluded that there would be a significant impact. Having to meet the resultant lower requirements would place a very heavy economic burden on Ontario Hydro. Thus, adopting a level of 100 Bq/l for tritium, averaged annually, would not have an immediate impact on Ontario Hydro, but would inevitably lead to a major financial impact. In fact, since the plants were not originally designed to achieve zero discharge, it may never be possible to modify them to achieve the required reductions.

In conclusion, the ACES recommendations differ markedly from international practices for regulating exposure to radioactivity in drinking water and if adopted, would place a heavy economic burden on Ontario Hydro for measures required to reduce its radioactive emissions. Remaining consistent with international standards for drinking water would have little economic impact on Ontario Hydro.

The attached study deals only with the costs of possible emission reduction measures. We hope the data we have provided will be used in a cost benefit analysis. Since we interpret the actual benefits which might be realized from adopting the ACES recommendations as being very low, we are looking forward to discussing your interpretation of these benefits as applied to the cost benefit analysis.

Please contact me at 592-7456 if you require clarification of this material or any further information.

Yours sincerely,

Ron Maruska

Ron Maruska
Technical Superintendent
Environment Department
Ontario Hydro Nuclear

att

cc. B. Thorpe
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K. Nash

A Submission to the Ministry of Environment and Energy on the Potential Impact of Reducing the Ontario Drinking Water Objective for Tritium

Submitted by Ontario Hydro

August 26, 1994

Ontario Hydro Submission to the MOEE on the Potential Impact of Reducing the Ontario Drinking Water Objective for Tritium

1.0 Introduction

In response to recent changes in the maximum dose limits recommended by the International Commission on Radiological Protection (ICRP) (ref. 1), drinking water guidelines for radionuclides are being revised downwards.

MOEE staff have recommended lowering the Ontario Drinking Water Objective (ODWO) for tritium from the current level of 40,000 Bq/L to 7,000 Bq/L (annual average).

The World Health Organization has recommended 7,800 Bq/L.

A report by the Advisory Committee on Environmental Standards (ACES) has recommended an immediate change to 100 Bq/L, a further reduction to 20 Bq/L within 5 years, and further reductions thereafter toward natural background levels of tritium. It was also recommended that these levels be applied on a "never to be exceeded" basis.

This document examines the potential impacts on Ontario Hydro of lower ODWO's for tritium. It attempts to provide as much as possible of the information requested (Attachment 1) by the MOEE (ref. letter Gaghadar to Maruska, June 30, 1994). However, only a limited amount of data and analysis has been possible because of the short time available for preparation.

2.0 Ontario Hydro Tritium Emission Performance

Ontario Hydro nuclear plant operation is regulated by the Atomic Energy Control Board (AECB). AECB emission limits for radionuclides are based on international standards (ICRP recommendations). Maximum annual emission levels are expressed as DELs (derived emission limits), in terms of the maximum allowable station release of tritium into water and reported in units of Curies (Ci) or Becquerels (Bq) per month. Station operating targets are to emit less than 1% of the current DEL for tritium (on a monthly average basis).

The DELs for tritium in water for the different nuclear stations are shown in Table 1 in terms of Tbq/y. The tritium DEL limit can also be used to calculate a concentration limit for tritium in the station outfall, i.e. the maximum allowable release of tritium in TBq/y divided by the total cooling water flow from the station for the year in litres. This is called the Derived Liquid Concentration (DLC). The DLC values for each station are also shown in Table 1.

Actual plant total tritium emissions to water over the last 5 years are shown in graphical form in Figure 1. Over this period, the 1% DEL operating target has never been exceeded.

Actual measured concentrations of tritium in drinking water at the water supply plants (WSPs) near the nuclear stations for approximately the past 10 years is shown in graphical form in Figures 2 to 11 (weekly average) and Figures 12 to 21 (annual average). From these data it can be seen that:

- The annual average concentrations have been quite low, ranging from 7 to 40 Bq/L over the past 10 years for all WSPs except for the Port Elgin WSP (77.9 Bq/L in 1991) and the Ajax WSP (72.5 Bq/L in 1988). Also, in the past 5 years (1989 to 1993) concentrations have dropped somewhat, ranging from 7.4 to 27.1 Bq/L except at Port Elgin (34.3-77.9 Bq/L).

- Tritium concentrations never exceeded the 40,000 Bq/L limit (annual average or weekly average).

- Concentrations never exceeded the proposed 7000 Bq/L (annual average, weekly average or daily average). Ontario Hydro would require no further programs in addition to those already in place for reduction of tritium emissions.

- Concentrations never exceeded 100 Bq/L on an annual average basis, but did exceed this level on a weekly average basis (shortest time period measured) as shown in Table 2, where the percentage of weeks exceeding 100 Bq/L is given. Ontario Hydro would require further tritium reduction actions to meet this level as recommended by ACES (i.e. if it were not applied as an annual average).

- Tritium levels frequently exceeded 20 Bq/L on an annual average basis or on a weekly average basis. Ontario Hydro would require further tritium reduction measures on a broad scale to meet this proposed limit, no matter what averaging period is applied.

The actual radiation dose from tritium in drinking water to the most affected members of the public living near Ontario Hydro nuclear stations is exceedingly small, typically from 0.003 to 0.8 uSv in 1993 (Ref 2,3,4,5,6 --Dose Summary reports for 1989-1993 inclusive - see section on drinking water).

3.0 Tritium Emission Sources and Trends

3.1 Identification of Key Sources of Tritium from Ontario Hydro Nuclear Plants

Tritium is produced from neutron activation of the heavy water systems in a CANDU reactor, i.e. the moderator system (containing 10-30 Ci of tritium per kg of D_2O) and the heat transport system (1-2 Ci/kg). Tritium is an unavoidable byproduct of reactor operation. See Figure 22 for a simplified CANDU power reactor flow diagram.

3.1.1 Minor Leakage, Maintenance and Housekeeping

A very small amount of tritium escapes from the heavy water systems due to minor equipment leakage during normal operation and from maintenance activities. The station design includes a D_2O recovery system where leakage with expected higher D_2O concentrations is collected, purified, upgraded and reused. There are relatively small D_2O/tritium losses from the upgraders.

The remaining leakage sources are fed via the active drainage system to the Active Liquid Waste system. This system also collects contaminated water from a large number of other minor sources. Figures 23, 24 and 25 are flow diagrams of the active liquid waste (ALW) systems for PNGS, DNGS and BNGS-A which include a list of the contributing minor sources. Although these sources are identified, not all are monitored individually because the tritium levels are extremely low and further monitoring is not warranted. The aggregate liquid waste collected in the ALW system tanks is sampled and analyzed, treated if necessary and then pumped out to the lake via the CCW discharge. However, tritium cannot be removed by any of this system's treatment methods (decay tanks, filtration and ion exchange).

Smaller amounts of tritium are released from housekeeping activities such as laundry and tool decontamination. These are also collected in the ALW system.

3.1.2 Equipment Failure

Potentially larger amounts of tritium may escape in the event of internal equipment failure, releasing D_2O and tritium to light water systems (e.g. lake cooling water).

Some heat exchangers, such as the moderator heat exchanger are cooled directly by lake water (service water). Tritium emissions have occurred as a result of a heat exchanger (HX) tube leak or rupture. Service water has been monitored for radioactivity regularly. However, some tritium has escaped from stations before the faulty equipment was shut down and isolated. PNGS has very recently improved their leak detection capability by installing on-line tritium monitors in their reactor building service water (RBSW) effluent stream.

Because of station design differences, RBSW effluent at PNGS is a separate discharge to the station outfall while at BNGS-A, BNGS-B and DNGS, RBSW effluent empties into the CCW discharge before leaving the station.

Another key source of tritium via equipment failure is the boilers. Although not cooled directly by lake water, a tube leak (of heat transport D_2O) in a boiler results in contamination of the secondary light water side. Boiler blowdown is used to remove some of the sediments that build up on the light water side, and boiler blowdown is drained to the CCW discharge. This provides a pathway for tritium from boiler tube leaks to the lake. Small boiler tube leaks may be tolerated during operation, but are monitored for tritium emissions to ensure they remain below operating targets. Development of a larger leak results in a reactor shutdown and boiler repairs to eliminate the leak. Boiler problems have contributed to tritium emissions over the last several years.

Some tritium emissions have also been caused by leaks from other heat exchangers containing D_2O, but the moderator heat exchangers and the boilers have been the major sources in the heat exchanger category.

3.2 Data/Estimates of Tritium Releases from Key Sources

Tritium emission data for the past 5 years (1989 to 1993) is included in Table 3. These data are the annual station total tritium emissions. More detailed data, providing weekly or monthly emission data and some providing discrete source data is included for the past 3 years (1991 to 1993).

3.2.1 PNGS

Monthly data for tritium to water emissions for PNGS for 1991, 1992, 1993 and 6 months of 1994 are given in Tables 4, 5 and 6. Tritium emissions data for PNGS-A are available for several sources, namely the CCW effluent, RBSW, Upgrader effluent (UPP and Sulzer), sewage and Auxiliary Irradiated Fuel Bay (AIFB) effluent. Data for PNGS-B are only for CCW effluent and RBSW. The upgraders, sewage system and AIFB are all shared with PNGS-A.

Looking at the combined PNGS-A and PNGS-B tritium emissions, the CCW pathway (essentially ALW system releases) normally contributes 40%-70% of the total tritium emissions, with most of the remainder from the RBSW effluent. 1992 RBSW emissions were unusually high as the result of a large single event release of tritium from a tube rupture in a moderator heat exchanger (August 1992).

3.2.2 BNGS-A

Weekly data for tritium emissions to water are given for BNGS-A for 1991, 1992 and 1993 in Table 7. This data is not available broken down into component sources. However, incidences of tritium emissions that were clearly higher than usual correlated with instances of equipment failures such as boiler or heat exchanger leaks.

The annual contribution from equipment leaks was estimated as the excess tritium above normal emission levels when these leaks occurred. According to these estimates, the contribution from operation without equipment failures was 29% to 71% of the total (3 year average 47%), while equipment failures (mostly boiler leaks) contributed the remainder (3 year average 53%). Better data could not be obtained in the time period available to prepare this report.

3.2.3 BNGS-B

Weekly data for tritium emissions to water are given for BNGS-B for 1991, 1992 and 1993 in Table 8. No breakdown or estimate of component sources of tritium emissions is available for BNGS-B.

3.2.4 Darlington

Monthly tritium emissions to water data are available for 1993 in Table 9. No breakdown or estimate of component sources of tritium emissions is available for DNGS.

3.2.5 Summary

A summary of annual emissions from all stations is given in Table 10.

3.3 Existing Programs and Initiatives that May Affect Future Tritium Releases

There are no existing provincial programs which may affect future tritium releases, except for the potential impact if the MOEE chooses a new ODWO for tritium which is very low. However, there are other provincial programs (MISA, Air Management Initiative, Phase Out of Ozone Depleting Substances) which are placing a large cost burden on Ontario Hydro.

There are no specific federal programs affecting future tritium releases, other than the ongoing enforcement by the AECB of the ALARA principle (keep emissions As Low As Reasonably Achievable, social and economic factors being taken into account). This is a continuous process which may affect future emissions.

There are existing programs within Ontario Hydro which are intended to reduce future tritium emissions.

Specific programs are now in place for minimizing leakage/failures in the boilers and major heat exchangers.

1) The boiler program includes improved chemical control, inspections, water lancing, tube plugging and electrosleeving (a new technological development pioneered by Ontario Hydro for boiler tube repair).

2) Aging moderator heat exchangers are being inspected, repaired and/or replaced.

These programs should reduce the frequency of occasional higher than normal emissions.

3) The existing tritium management program consists of sending D_2O from all Ontario Hydro nuclear stations to the Tritium Removal Facility located on the Darlington NGS site where the D_2O is treated to remove much of the tritium and then returned to the station of origin. The extracted tritium is immobilized as a metal hydride and stored safely on site. Without the TRF, equilibrium tritium concentrations would be about 40 Ci/kg of moderator D2O and 2 Ci/kg of heat transport D_2O (ref.7). The TRF is meant to achieve and maintain lower equilibrium tritium levels of about 15 Ci/kg moderator and 1 Ci/kg heat transport. The 1993 average tritium concentrations were 13.99 Ci/kg moderator and 1.16 Ci/kg heat transport (ref. 8). This program reduces the impact of both the regular emissions from a large number of small sources and the occasional emissions from equipment failures.

4.0 Abatement Cost Functions

4.1 Feasible Technologies and Actions that can Reduce Tritium by Each Key Source

The ALW system and major heat exchangers such as the boilers and moderator heat exchangers have been identified as the key sources of tritium emissions.

4.1.1 Active Liquid Waste Management System

The ALW system hold up tanks contain a collection of waste light (ordinary) water contaminated with very small amounts of radioactivity. This waste water comes from a large number of small sources.

1) Option One: Pollution Prevention Studies

One option for reducing the tritium in the ALW system is to undertake a large extensive study and monitoring program to characterize each of the sources and pathways that feeds the ALW system, in the hope that a small number of sources may be identified as the major contributors. It may then be possible to reduce tritium losses from those sources. Such a study would be required at each station because of differences in design and operation. The cost of the study might be about $0.5 million, but further work would be required to produce an estimate. However, it should also be noted that following the ALARA (as low as reasonably achievable) principle, emission source reduction has always been a part of normal operations.

It is unknown if better source characterization upstream of the ALW system would lead to any significant reduction in tritium emissions or what this would cost. This type of data has not been collected to date because it was not needed, i.e. the total amount of tritium collected in ALW from all sources combined is small. It falls well below the operating target of 1% of the maximum AECB release limit. Furthermore, maintenance and housekeeping procedures have always been in place to minimize the loss of D_2O (and thus tritium), not only to keep emissions low, but also for economic reasons as D_2O is very costly (nominally about $400 per kg).

2) Option 2: Detritiation of Waste Water

Another option is to remove the very low concentration tritium from all the collected waste water in the ALW system before it is released to the lake. The TRF is not suitable for treating large volumes of water with such low tritium concentrations. The only feasible method of removing this tritium is by vacuum distillation. The detritiation factor would be about 1000 to 1. This process is a proven technology and is used at Ontario Hydro for upgrading heavy water that is contaminated with ordinary water.

It is estimated that total ALW volume is about 120,000 m3/y. The largest distillation unit in Ontario Hydro has a feed rate of 1,000 kg/hr. Thus, the ALW volume could be handled by about 15 such units. Based on the cost of existing Ontario

Hydro equipment, the capital cost of such a distillation process to handle the ALW of all Ontario Hydro nuclear stations would be well over $500 million. Operating costs have not been well estimated, but are expected to be many millions of dollars because of the high energy usage required by this system. The total cost of building and operating such detritiation units for all nuclear stations could exceed a billion dollars.

Figure 26 shows a schematic of a proposed Waste Water Detritiation Process. It would consist of a prefilter, evaporator, distillation towers, reboilers, vacuum pumps, heat exchangers and storage tanks. The concentrated product can be immobilized for low cost storage, or further treated by electrolysis or cryogenic distillation.

4.1.2 Equipment Leaks/Failures

1) Option 1: Improve Leak Detection

One option to minimize tritium emissions from equipment leaks and failures is to improve tritium detection and/or leak detection at appropriate locations in the plant. This would allow the faulty equipment to be located and isolated more quickly, thus reducing the amount of tritium released. At present, PNGS is reviewing their tritium leak detection and response capability for all nuclear process systems discharging to the lake. A new type of continuous on-line tritium monitor is being tested at PNGS to improve the detection and monitoring of tritium in water. An estimate for the cost of the study and the new tritium monitors is not available at this time.

The cost and effectiveness of implementing other leak detection/response measures will not be known until the PNGS study is completed.

2) Option 2: Improve Inspection and Maintenance

Another option to reduce tritium emissions from equipment leaks is to minimize corrosion and to improve the inspection and maintenance programs for such equipment. Such programs have already been implemented and are ongoing.

3) Option 3: Boiler Blowdown Recovery

A third option would apply to the boilers. Tritium which leaks to the light water side of the boilers is released to the lake via boiler blowdown. The boiler blowdown system could be modified so that it is a closed loop system, thus eliminating direct tritium releases to the lake. However, it would result in a buildup of tritium in the boiler/feedwater/steam system. This would likely increase emissions of tritium to air until the tritium in this system could be removed (requires a new vacuum distillation process described above). The cost of modifying the boiler blowdown systems of all nuclear plants has been estimated at about $150 million.

4) Option 4: Closed Loop Cooling for Heat Exchangers

A fourth option for tritium reduction is to provide another layer of containment for heat exchangers, i.e. modify all heat exchangers that are now cooled directly by lake water so that they provide closed loop cooling to the nuclear systems and these closed loop systems are in turn cooled by lake water through additional heat exchangers. Again, without the elimination of primary equipment leaks, such a modification would result in secondary light water systems contaminated with more tritium and would require eventual detritiation via the vacuum distillation process described above.

The cost of modifying all heat exchangers cooled directly by lake water and adding another cooling system for each was not estimated, but would be prohibitively costly if it were even feasible, given the physical constraints of existing plant.

5) Option 5: Replace Aging Equipment Sooner

A fifth option to minimize occasional unexpected equipment failures (and thus tritium emissions) would be to replace aging equipment much sooner than currently planned. Considering the cost of major heat exchangers and boilers (hundreds of millions to billions of dollars), this would be a prohibitively costly measure.

5.0 Conclusions

Over the past 5 years tritium levels at WSPs around Ontario Hydro nuclear stations normally range from 7 to 27 Bq/L with the Port Elgin WSP somewhat higher at 34 to 78 Bq/L. They occasionally exceed 100 Bq/L (see Table 2 for frequency of exceedance) on a weekly average (or shorter) basis, but never on an annual average basis. The 20 Bq/L level is exceeded frequently for all averaging periods, weekly, monthly and annually. When the tritium emission data is examined, it appears at first glance that normal station operation would cause tritium at WSPs to exceed 20 Bq/L much of the time, but that instances where 100 Bq/L is exceeded are caused by specific equipment leaks or failures. Although this may be the case, we have not had the time to do a proper analysis to confirm this hypothesis.

Based on the MOEE request to look only at the potential impact of reducing tritium emissions, in relation to lowering the ODWO for tritium to an as yet undetermined level, we conclude the following:

- If the ODWO were set to the level recommended by the World Health Organization or MOEE staff, namely 7800 to 7000 Bq/L, there would be little economic impact on Ontario Hydro. This conclusion is based on the data for tritium in WSPs near Ontario Hydro nuclear stations. The data show that over the past 10 years tritium levels have never exceeded 7000 Bq/L.

- If the ODWO were set to the level recommended by ACES, namely 100 Bq/L on a "never to be exceeded" basis, there would be a heavy financial impact on Ontario Hydro. The 100 Bq/L level is exceeded regularly but not frequently, as can be seen from examining the weekly average WSP tritium data over the past 10 years. Existing programs implemented at the nuclear stations will reduce the risk of failure of equipment containing heavy water, but will not guarantee that the 100 Bq/L level would never be exceeded. To do so would involve implementing extreme measures such as the extensive equipment modifications described above and the use of a new detritiation facility. The cost would be in the billions of dollars. Furthermore, if these measures were not totally effective, more frequent reactor shutdowns would be required to stay below the limit, resulting in increased emissions from CO_2 and acid gases from the replacement fossil fired power generation.

- If the ODWO were set to 20 Bq/L as recommended by ACES, it would be necessary to implement a new vacuum distillation detritiation plant for removing low tritium concentrations from large volumes of waste light water. Significant equipment modifications to avoid D_2O/tritium leaks would also be required as described above. Costs were estimated at over a billion dollars for each of these options.

- If ODWO for tritium were set to 100 Bq/L annual average, then it appears that there would be little additional economic impact on Ontario Hydro. However, we are convinced that there will be a very large economic impact for the following reasons:

  This socio-economic study is focusing on tritium in drinking water only, to the exclusion of all other radionuclides in drinking water, and ignoring the exposure to residents near a nuclear plant from all the plant's other radioactive emissions. If the 100 Bq/L limit is chosen for tritium, and with it the risk basis of 5 in a million, it would be inconceivable that the same risk basis should not be applied to each radionuclide emitted. The potential health effects from exposure to tritium are no different than for other radionuclides, and the public would expect consistent regulations for all exposures.

If the 5 in a million risk level were applied to all of our radioactive emissions, Ontario Hydro would have to reduce its radioactive emissions to air by up to a factor of about 7-fold. Emissions of tritium, carbon-14 and radioactive noble gases to air would all be affected. Table 11 presents the emission reduction factors which would be required to meet the lower risk factors recommended by ACES. These factors are based on an analysis of Ontario Hydro measured dose impacts for 1993 (Ref. 6). There was insufficient time to extend this analysis back 5 years. Reductions would be required whether the risk factor were applied individually to each radionuclide for each pathway, or for multiple pathways.

For a lifetime risk factor of one in a million, reductions for emissions to air would be required for noble gases, carbon-14, tritium and particulates. The reduction factors would be considerably higher, up to a factor of 34.

For Carbon-14, the natural background level of about 250 Bq/kg-C already exceeds the maximum concentration that would be allowed for a lifetime risk level of 5 in a million for consuming milk, fruits and vegetables. For the risk level of one in a million, natural background levels would exceed the maximum allowable concentrations for the consumption of milk, fruits, vegetables and fish.

The economic impact of having to make these emission reductions has not been evaluated, but is expected to be very large. Since the plants were never designed for zero discharge, it may never be possible to modify them to achieve the required reductions. A substantial amount of time and effort would be required to evaluate the feasibility and cost of achieving these proposed lower emission limits.

TABLE 1

EMISSION LIMITS FOR TRITIUM IN WATER

	Pickering A	Pickering B	Darlington	Bruce A	Bruce B
Derived Emission Limit (DEL), TBq/y	8.4E+05 (pre-1991) 6.2E+05 (post-1991)	8.4E+05 (pre-1991) 6.2E+05 (post-1991)	5.3E+06	1.7E+06	3.0E+06
Operating Target, TBq/y (based on 1% DEL)	8.4E+03	8.4E+03	5.3E+04	1.7E+04	3.0E+04
CCW full power cooling flow, m3/a *	3.0E+09	3.0E+09	4.5E+09	4.8E+09	4.9E+09
Derived Liquid Concentration, Bq/L	2.1E+05	2.1E+05	1.2E+06	3.5E+05	6.1E+05
Operating Target, Bq/L (based on 1% DEL)	2.1E+03	2.1E+03	1.2E+04	3.5E+03	6.1E+03

* NOTE: In Normal operation, actual cooling water flow may be lower than this maximum value, providing smaller dilution factors.

Table 2

Weekly Average Tritium Concentration Frequency Chart*

Drinking Water Sources	Weeks of Data (#)	Weekly Average Tritium Concentration Frequency Chart (%)		
		≥20 Bq/L	≥100 Bq/L	
Kincardine WSP	528	12.3	0.4	not si... '87
Pt. Elgin WSP	528	73.7	8.5	> 1/4
St. Mary's Cement Plant	221	19.5	0.5	88 on...
Bowmanville WSP	384	13.3	0.3	88 on...
Newcastle WSP	384	14.3	0	∅
R.C. Harris WSP	528	11.4	0.2	92 on...
Scarborough WSP	528	11.9	0.4	92 on..., (87...
Ajax WSP	450	45.3	4.9	86, 87, 9...
Oshawa WSP	528	30.7	1.7	87, 88 ...
Whitby WSP	216	10.6	0.5	92 on...

* PERIOD: 1983 - 1993

REFERENCES

1. ICRP Publication 60, 1990 Recommendations of the International Commission on Radiological Protection, 1991

2. Annual Summary and Assessment of Environmental Radiological Data for 1989, HSD-TS-90-4, Senes Consultants.

3. Annual Summary and Assessment of Environmental Radiological Data for 1990, HSD-HP-91-20, W. Chrisitani.

4. Annual Summary and Assessment of Environmental Radiological Data for 1991, HSD-HP-92-9, W. Chrisitani.

5. Annual Summary and Assessment of Environmental Radiological Data for 1992, HSD-HP-93-9, W. Chrisitani.

6. Annual Summary and Assessment of Environmental Radiological Data for 1993, N-03419-940035-P-OUO, J. LaMarre.

7. W.J. Holtslander, T.S> Drolet and R.V. Osborne, Recovery of Tritium from Candu Reactors, its Storage and Monitoring of its Migration in the Environment, July 1979.

8. Ontario Hydro 1993 Environment Performance Report.

ATTACHMENT I

INFORMATION NEEDS TO REVIEW IMPLICATIONS OF RECOMMENDATIONS OF ACES ON A NEW ODWO FOR TRITIUM

IDENTIFY SOURCES AND TRENDS OF POLLUTANTS

Intent: Identify key sources of tritium in the relevant plants

Key Tasks:

a. Can you identify key sources of tritium from your plants?

b. Please assemble data/estimates of past and present (over the past five years) tritium releases from the key sources identified in (a). This will define "base case pollution level" from which technologies will reduce pollutant releases.

c. What provincial, federal and external programs and initiatives exist that may effect future tritium releases.

DEVELOP ABATEMENT COST FUNCTIONS

Intent: Derive abatement cost functions for specific key sources and aggregate to get cost function for all sources. The range of options should include at least two polar scenarios - Do nothing and the maximum technically feasible degree of control.

Key Tasks:

a. Define feasible technologies and actions that can reduce tritium by each key source. Note compatibilities of technologies among sources for combining them into "technology trains". A Technology/Action combination that can be installed at a source is called an "Abatement Program".

b. For each Abatement Program, develop estimates of:

i. Tritium reduction efficiencies and discharge reductions,
ii. Capital and operating costs of application to specific sources in Ontario.
iii. Potential for inter-media contaminant transfers.
iv. Range of uncertainty for estimates.

c. Menu of Abatement Programs for all sources will be used to generate aggregate abatement cost functions that will be used to evaluate range of potential Provincial standards.

TABLE 3

Tritium in Water Emission Trends 1989 to 1993

Year	Actual Emissions (TBq/y)					
	Pickering A	Pickering B	Pickering A+B	Darlington	Bruce A	Bruce B
1989	5.8E+02	8.4E+01	6.6E+02	2.1E+00	1.6E+03	3.3E+02
1990	3.9E+02	3.0E+01	4.2E+02	1.3E+01	1.2E+03	4.4E+02
1991	4.0E+02	3.2E+01	4.3E+02	7.1E+01	3.2E+03	4.9E+02
1992	3.0E+03	4.4E+01	3.1E+03	4.9E+01	1.7E+03	4.1E+02
1993	5.3E+02	3.9E+01	5.7E+02	5.8E+01	1.5E+03	6.7E+02

TABLE 4 (PAGE 1 OF 3) - PNGS EMISSIONS, 1991
TRITIUM IN WATER

Pickering A NGS Tritium Releases 9101 to 9112

		Tritium Avg uCi/ml	max con uCi/ml	Bq/L	Total Act Ci/mth	Bq/mth	Vol m3/mth
CCW effluent							
	9101	1.01E-05			1.73E+03		
	9102	1.28E-06			2.24E+02		
	9103	3.11E-06			4.90E+02		
	9104	7.95E-06			9.29E+02		
	9105	3.69E-06			4.54E+02		
	9106	1.54E-06			3.38E+02		
	9107	1.79E-06			3.70E+02		
	9108	1.27E-06			2.95E+02		
	9109	3.00E-06			7.98E+02		
	9110	6.55E-06			9.51E+02		
	9111	1.58E-06			2.76E+02		
	9112	1.85E-06			3.79E+02		
avg		3.64E-06			6.03E+02	2.23E+13	
sum					7.23E+03		
UPP-B Effluent							
	9101	3.62E-06			1.31E+00		
	9102	6.24E-06			2.26E+00		
	9103	4.19E-06			1.90E+00		
	9104	1.34E-05			4.89E+00		
	9105	5.19E-06			1.88E+00		
	9106	3.67E-06			1.66E+00		
	9107	3.89E-05			1.41E+01		
	9108	4.91E-05			1.78E+01		
	9109	1.78E-05			8.11E+00		
	9110	2.55E-05			9.27E+00		
	9111	3.89E-05			1.41E+01		
	9112	6.61E-06			2.11E-05		
avg		1.78E-05			6.44E+00	2.38E+11	
sum					7.73E+01		
UPP-A Effluent							
	9101	6.04E-06			6.91E+00		
	9102	5.74E-06			6.56E+00		
	9103	6.39E-06			9.13E+00		
	9104	1.49E-05			1.71E+01		
	9105	7.07E-06			8.08E+00		
	9106	5.09E-06			7.28E+00		
	9107	7.69E-06			8.79E+00		
	9108	4.22E-06			4.82E+00		
	9109	8.01E-06			1.14E+01		
	9110	5.39E-06			6.16E+00		
	9111	1.40E-06			1.60E+00		
	9112	1.72E-05			2.46E+01		
avg		7.43E-06			9.37E+00	3.47E+11	
sum					1.12E+02		
Township Sewage							
	9101	3.53E-05			2.96E+01		
	9102	2.34E-05			1.96E-01		
	9103	1.61E-05			1.70E-01		
	9104	1.47E-05			1.23E-01		
	9105	2.74E-05			2.30E-01		
	9106	1.09E-04			1.14E+00		
	9107	3.71E-05			3.12E-01		
	9108	3.31E-05			2.78E-01		
	9109	2.07E-05			2.17E-01		
	9110	3.20E-05			2.68E-01		
	9111	1.14E-05			9.61E-02		
	[illegible]	[illegible]			5.44E-02		

TABLE 4 (PAGE 2 of 3) - PNGS EMISSIONS, 1991
TRITIUM IN WATER

avg		3.04E-05	2.72E+00	1.01E+11
sum			3.27E+01	
		Tritium Avg. (µCi/ml)	Total Activity (Ci/mo.)	Bq/mo.
RBSW Effluent				
	9101	9.17E-06	2.46E+02	
	9102	6.49E-06	1.74E+02	
	9103	2.10E-05	7.06E+02	
	9104	1.39E-05	3.76E+02	
	9105	2.99E-06	8.05E+01	
	9106	0.00E+00	0.00E+00	
	9107	0.00E+00	0.00E+00	
	9108	2.02E-06	5.43E+01	
	9109	9.75E-06	3.27E+02	
	9110	1.18E-05	3.17E+02	
	9111	1.23E-05	3.25E+02	
	9112	1.47E-05	4.96E+02	
avg		8.68E-06	2.58E+02	9.56E+12
sum			3.10E+03	
AIFB Effluent				
	9101	0.00E+00	0.00E+00	
	9102	8.74E-06	1.52E+00	
	9103	1.39E-06	1.02E-01	
	9104	2.74E-06	1.58E-01	
	9105	0.00E+00	0.00E+00	
	9106	1.14E-05	1.06E+00	
	9107	2.74E-06	2.40E-01	
	9108	0.00E+00	0.00E+00	
	9109	0.00E+00	0.00E+00	
	9110	4.07E-06	4.51E-01	
	9111	4.93E-06	5.25E-01	
	9112	2.14E-05	3.11E+00	
avg		4.78E-06	5.97E-01	2.21E+10
sum			7.17E+00	
Sulzer A SW Effluent				
	9101	9.88E-05	3.68E+00	
	9102	2.44E-06	9.13E-02	
	9103	2.61E-06	1.22E-01	
	9104	4.49E-06	1.67E-01	
	9105	6.62E-06	2.46E-01	
	9106	0.00E+00	0.00E+00	
	9107	3.12E-05	1.16E+00	
	9108	3.49E-06	1.30E-01	
	9109	5.92E-06	2.76E-01	
	9110	5.32E-05	1.98E+00	
	9111	2.34E-05	8.74E-01	
	9112	4.21E-05	1.96E+00	
avg		2.29E-05	8.91E-01	3.29E+10
sum			1.07E+01	
Sulzer B SW Effluent				
	9101	3.37E-04	6.60E+01	
	9102	9.89E-05	1.93E+01	
	9103	3.62E-05	8.86E+00	
	9104	2.69E-05	5.27E+00	
	9105	4.54E-05	8.87E+00	
	9106	3.27E-05	7.99E+00	
	9107	1.66E-05	3.25E+00	
	9108	1.67E-06		

TABLE 4 (PAGE 3 OF 3) – PNGS EMISSIONS, 1991
TRITIUM IN WATER

	9109	4.08E-06	9.98E-01	
	9110	1.21E-05	2.37E+00	
	9111	1.07E-05	2.10E+00	
	9112	2.13E-05	5.21E+00	
avg		5.36E-05	1.09E+01	4.03E+11
sum			1.31E+02	
Total 91 sum			1.06E+04	

Pickering B 91

		Tritium Avg uCi/ml	max con uCi/ml	Bq/L	Total Act Ci	Bq/mo.	Vol m3/mth
CCW effluent							
	9101	1.05E-06			2.45E+02		
	9102	1.07E-07			2.05E+01		
	9103	1.26E-07			3.60E+01		
	9104	0.00E+00			0.00E+00		
	9105	0.00E+00			0.00E+00		
	9106	0.00E+00			0.00E+00		
	9107	0.00E+00			0.00E+00		
	9108	0.00E+00			0.00E+00		
	9109	0.00E+00			0.00E+00		
	9110	2.95E-07			5.13E+01		
	9111	3.32E-07			5.78E+01		
	9112	0.00E+00			0.00E+00		
avg		1.59E-07			3.42E+01	1.27E+12	
sum					4.11E+02		
RBSW Effluent							
	9101	3.74E-06			1.00E+02		
	9102	1.49E-06			4.02E+01		
	9103	1.39E-06			4.70E+01		
	9104	1.74E-06			4.70E+01		
	9105	0.00E+00			0.00E+00		
	9106	2.39E-06			8.05E+01		
	9107	0.00E+00			0.00E+00		
	9108	0.00E+00			0.00E+00		
	9109	1.00E-06			3.36E+01		
	9110	0.00E+00			0.00E+00		
	9111	2.00E-06			5.37E+01		
	9112	1.16E-06			3.92E+01		
avg		1.24E-06			3.68E+01	1.36E+12	
sum					4.41E+02		
91 sum					8,52E+02		
Total Grand 91 sum					1.14E+04		

SUMMARY OF TOTAL EMISSIONS FROM PICKERING A + B FOR 1991

Total on annual report (TRITIUM)			1.10E+04		Average ov
CCW %	2.83E+14	7.64E+03	6.69E+01	67%	2.90E+14
RBSW	1.31E+14	3.54E+03	3.10E+01	31%	1.00E+15
UppB Effluent	2.86E+12	7.73E+01	6.76E-01	0.7%	1.76E+13
UPP A Effluent	4.16E+12	1.12E+02	9.84E-01	1%	2.76E+13
Sewage	1.21E+12	3.27E+01	2.86E-01		5.79E+11
AIFB	2.65E+11	7.17E+00	6.27E-02		1.86E+11
Sulzer A	3.95E+11	1.07E+01	9.35E-02		1.43E+12
Sulzer B	4.83E+12	1.31E+02	1.14E+00		2.99E+12
Sulzer B			1.01E+02		
	Bq/a	Ci/a	% of total		Bq/a
			91		

TABLE 5 - PNGS EMISSIONS FOR 1992 (Pg. 1 of 3)
TRITIUM IN WATER

Pickering A NGS Tritium Releases 9201 9212

		Tritium Avg uCi/ml	max con uCi/ml	Bq/L	Total Act Ci/mth	Bq/mth	Vol m3/mth
CCW effluent							
	9201	3.25E-06	5.41E-04		5.52E+02		
	9202	2.81E-06	7.84E-04		4.74E+02		
	9203	4.78E-06	3.87E-04		1.04E+03		
	9204	1.41E-06	4.97E-05		2.46E+02		
	9205	2.14E-06	4.10E-04		3.73E+02		
	9206	2.88E-06	3.65E-04		6.28E+02		
	9207	8.30E-07	2.12E-05		1.45E+02		
	9208	7.74E-06	1.35E-03		1.29E+03		
	9209	3.91E-06	2.09E-04		6.96E+02		
	9210	1.68E-06	8.99E-05		2.46E+02		
	9211	5.78E-05	3.45E-04		8.42E+02		
	9212	1.58E-05	1.94E-03		2.98E+03		
avg		8.75E-06			7.93E+02	2.93E+13	9.06E+07
sum					9.51E+03		
UPP-B Effluent							
	9201	5.90E-05	1.38E-04		2.14E+01		
	9202	2.62E-05	5.29E-05		9.51E+00		
	9203	1.04E-04	3.24E-04		4.71E+01		
	9204	4.22E-04	5.30E-04		1.53E+02		
	9205	2.92E-04	3.22E-04		1.06E+02		
	9206	8.65E-05	1.76E-04		3.92E+01		
	9207	6.93E-05	1.63E-04		2.51E+01		
	9208	1.90E-04	3.30E-04		6.91E+01		
	9209	9.82E-05	1.72E-04		4.45E+01		
	9210	6.30E-05	9.58E-05		2.28E+01		
	9211	4.11E-05	5.64E-05		1.49E+01		
	9212	7.67E-05	1.25E-04		3.47E+01		
avg		1.27E-04			4.89E+01	1.81E+12	
sum					5.87E+02		
UPP-A Effluent							
	9201	3.68E-05	7.90E-05		4.21E+01		
	9202	1.37E-04	1.72E-04		1.56E+02		
	9203	1.59E-04	2.45E-04		2.27E+02		
	9204	3.92E-04	4.82E-04		4.48E+02		
	9205	2.81E-04	4.53E-04		3.21E+01		
	9206	6.11E-05	1.06E-04		8.73E+01		
	9207	5.35E-05	1.57E-04		6.12E+01		
	9208	9.08E-06	1.23E-04		1.03E+01		
	9209	5.4E-05	7.68E-05		7.71E+01		
	9210	3.30E-05	6.24E-05		3.77E+01		
	9211	2.74E-05	4.93E-05		3.14E+01		
	9212	2.71E-04	6.30E-05		3.87E+01		
avg		1.26E-04			1.04E+02	3.85E+12	
sum					1.25E+03		
Township Sewage							
	9201	2.77E-05			2.33E-01		
	9202	1.57E-05			1.32E-01		
	9203	6.05E-04			6.35E-01		
	9204	2.00E-05			1.68E-01		
	9205	1.82E-05			1.53E-01		
	9206	1.75E-05			3.21E-01		
	9207	1.44E-05			2.12E-01		
	9208	6.91E-05			1.01E+00		
	9209	2.31E-04			4.25E+00		
	9210	4.13E-05			6.08E-01		
	9211	1.81E-05			2.61E-01		

TRITIUM IN WATER

avg		9.45E-05			6.74E-01	2.49E+10
sum					8.09E+00	

		Avg. µCi/ml	max conc. µCi/ml	Bq/L	Total Act. Ci/mo.	Bq/mo.
RBSW Effluent						
	9201	1.19E-05	2.24E-05		3.20E+02	
	9202	8.54E-06	2.01E-05		2.29E+02	
	9203	2.24E-05	4.02E-05		7.52E+02	
	9204	3.71E-05	4.26E-05		9.98E+02	
	9205	4.09E-05	4.81E-05		1.10E+03	
	9206	3.62E-05	4.90E-05		1.21E+03	
	9207	4.99E-05	4.28E-05		1.07E+03	
	9208	2.27E-03	9.06E-03		6.10E+04 (Mod.Leak)	
	9209	3.85E-05	7.89E-05		1.29E+03	
	9210	3.54E-05	6.94E-05		9.52E+02	
	9211	5.62E-06	1.29E-05		1.51E+02	
	9212	1.51E-05	3.83E-05		5.09E+02	
avg		2.14E-04			5.80E+03	2.15E+14
sum					6.96E+04	

AJFB Effluent						
	9201	8.50E-05			1.00E+00	
	9202	0.00E+00			0.00E+00	
	9203	0.00E+00			0.00E+00	
	9204	0.00E+00			0.00E+00	
	9205	0.00E+00			0.00E+00	
	9206	0.00E+00			0.00E+00	
	9207	1.59E-06			2.54E-01	
	9208	0.00E+00			0.00E+00	
	9209	1.01E-06			2.31E-01	
	9210	1.99E-06			3.42E-01	
	9211	0.00E+00			0.00E+00	
	9212	1.96E-06			4.46E-01	
avg		7.63E-06			1.89E-01	7.01E+09
sum					2.27E+00	

Sulzer A SW Effluent						
	9201	6.47E-05			2.41E+00	
	9202	3.70E-05			1.38E+00	
	9203	0.00E+00			0.00E+00	
	9204	2.43E-04			9.06E+00	
	9205	5.18E-04			1.93E+01	
	9206	1.11E-04			5.21E+00	
	9207	5.38E-05			2.00E+00	
	9208	2.47E-04			9.23E+00	
	9209	9.00E-05			4.19E+00	
	9210	7.52E-05			2.80E+00	
	9211	1.58E-03			5.89E+00	
	9212	2.35E-04			1.09E+01	
avg		2.71E-04			6.03E+00	2.23E+11
sum					7.24E+01	

Sulzer B SW Effluent						
	9201	3.48E-05			6.81E+00	
	9202	1.61E-05			3.15E+00	
	9203	1.12E-04			5.25E+00	
	9204	1.24E-04			2.43E+01	
	9205	6.64E-05			1.29E+01	
	9206	6.33E-05			1.54E+01	
	9207	2.92E-05			5.71E+00	
	9208	4.23E-06			8.27E-01	

TABLE 5 - PNGS EMISSIONS FOR 1992 (pg. 3 of 3)
TRITIUM IN WATER

	9209	4.56E-05	1.11E+01	
	9210	3.46E-05	6.76E+00	
	9211	4.24E-06	8.30E-01	
	9212	0.00E+00	0.00E+00	
avg		4.45E-05	7.75E+00	2.87E+11
sum			9.30E+01	

Total 92 sum	8.10E+04

Pickering B 92

		Tritium Avg uCi/ml	max con uCi/ml	Bq/L	Total Act Ci/mth		Vol m3/mth
CCW effluent							
	9201	0.00E+00			0.00E+00		
	9202	0.00E+00			0.00E+00		
	9203	0.00E+00			0.00E+00		
	9204	0.00E+00			0.00E+00		
	9205	0.00E+00			0.00E+00		
	9206	0.00E+00			0.00E+00		
	9207	1.58E-07			2.75E+01		
	9208	0.00E+00			0.00E+00		
	9209	0.00E+00			0.00E+00		
	9210	0.00E+00			0.00E+00		
	9211	0.00E+00			0.00E+00		
	9212	0.00E+00			0.00E+00		
avg		1.32E-08			2.29E+00	8.48E+10	
sum					2.75E+01		

RBSW Effluent				
	9201	3.39E-06	9.11E+01	
	9202	1.34E-06	3.61E+01	
	9203	0.00E+00	0.00E+00	
	9204	4.73E-06	1.27E+02	
	9205	3.85E-06	1.03E+02	
	9206	4.11E-06	1.38E+02	
	9207	2.39E-05	6.43E+02	
	9208	1.84E-06	4.96E+01	
	9209	0.00E+00	0.00E+00	
	9210	0.00E+00	0.00E+00	
	9211	0.00E+00	0.00E+00	
	9212	0.00E+00	0.00E+00	
avg		3.60E-06	9.90E+01	3.66E+12
sum			1.19E+03	

92 sum	1.22E+03

SUMMARY OF TOTAL TRITIUM EMISSIONS FROM PICKERING A + B FOR 1992

Total Grand 92 sum			8.22E+04	
Total on annual report			8.20E+04	
CCW %	3.53E+14	9.54E+03	1.16E+01	12%
RBSW	2.62E+15	7.08E+04	8.61E+01	86%
UppB Effluent	2.17E+13	5.87E+02	7.14E-01	
UPP A Effluent	4.62E+13	1.25E+03	1.52E+00	1.5%
Sewage	2.99E+11	8.09E+00	9.83E-03	
AIFB	8.41E+10	2.27E+00	2.76E-03	
Sulzer A	2.68E+12	7.24E+01	8.80E-02	
Sulzer B	3.44E+12	9.30E+01	1.13E-01	
			1.00E+02	
	Bq/a	Ci/a	% of total 92	

TRITIUM IN WATER

Pickering A NGS ALW 9301 to 9406

	Tritium Avg uCi/ml	max con uCi/ml	Bq/L	Total Act Ci/mth	Bq/mth	Vol m3/mth
CCW effluent						
9301	2.23E-06	1.01E-04		3.72E+02		1.67E+08
9302	1.48E-06	6.39E-05		3.37E+02		2.28E+08
9303	5.76E-06	2.12E-04		1.31E+03		2.27E+08
9304	1.67E-06	2.06E-04		3.47E+02		2.08E+08
9305	1.36E-06	8.85E-05		3.70E+02		2.72E+08
9306	3.62E-06	1.59E-04		6.30E+02		1.74E+08
9307	5.22E-06	1.14E-03		9.95E+02		1.91E+08
9308	2.33E-06	5.07E-04		6.75E+02		2.90E+08
9309	1.37E-06	6.90E-05		3.11E+02		2.27E+08
9310	8.11E-07	2.06E-05		1.81E+02		2.23E+08
9311	1.43E-06	5.29E-05		3.12E+02		2.18E+08
9312	1.85E-06	5.42E-05		3.70E+02		2.00E+08
9401	9.12E-07	3.18E-05		1.85E+02		2.03E+08
9402	3.02E-06	5.06E-04		7.54E+02		2.50E+08
9403	1.01E-06	2.70E-05		2.02E+02		2.00E+08
9404	1.13E-06	2.41E-05		2.64E+02		2.34E+08
9405	2.66E-06	3.66E-04		7.72E+02		2.90E+08
9406	2.52E-06	2.11E-04		5.85E+02		2.32E+08
avg	2.24E-06		8.30E+01	4.98E+02	1.84E+13	2.22E+08
93 sum				6.21E+03		
9394sum				8.97E+03		
UPP-B Effluent						
9301	1.35E-04	2.17E-04		4.90E+01		3.63E+05
9302	2.69E-04	4.32E-04		1.22E+02		4.54E+05
9303	1.68E-04	2.49E-04		6.11E+01		3.64E+05
9304	6.70E-05	1.44E-04		2.43E+01		3.63E+05
9305	7.10E-05	1.03E-04		3.22E+01		4.54E+05
9306	5.48E-05	8.02E-05		1.99E+01		3.63E+05
9307	1.38E-04	4.33E-04		5.02E+01		3.64E+05
9308	8.08E-05	1.61E-04		3.66E+01		4.53E+05
9309	9.67E-05	1.46E-04		3.51E+01		3.63E+05
9310	2.10E-04	3.23E-04		7.64E+01		3.64E+05
9311	1.39E-04	5.92E-04		1.53E+02		1.10E+06
9312	2.72E-04	3.48E-04		9.87E+01		3.63E+05
9401	2.12E-03	3.20E-03		7.71E+02		3.64E+05
9402	1.15E-03	2.68E-03		5.24E+02		4.56E+05
9403	5.53E-04	6.86E-04		2.00E+02		3.62E+05
9404	6.80E-04	1.19E-03		2.47E+02		3.63E+05
9405	6.13E-04	1.02E-03		2.78E+02		4.54E+05
9406	2.17E-04	2.92E-04		7.89E+01		3.64E+05
avg	3.91E-04		1.45E+04	1.59E+02	5.87E+12	4.06E+05
93 sum				7.59E+02		
9394sum				2.86E+03		
UPP-A Effluent						
9301	5.49E-05	7.13E-05		6.28E+01		1.14E+06
9302	8.87E-05	1.76E-04		1.26E+02		1.42E+06
9303	7.66E-05	1.06E-04		8.75E+01		1.14E+06
9304	5.31E-05	8.70E-05		6.06E+01		1.14E+06
9305	4.99E-05	1.14E-04		7.13E+01		1.43E+06
9306	6.54E-05	8.82E-05		7.47E+01		1.14E+06
9307	1.84E-05	5.02E-05		2.10E+01		1.14E+06
9308	4.54E-05	8.37E-05		6.49E+01		1.43E+06
9309	1.37E-05	3.71E-05		1.56E+01		1.14E+06
9310	4.95E-05	1.20E-04		5.66E+01		1.14E+06
9311	1.14E-04	3.07E-04		1.63E+02		1.43E+06
9312	6.40E-05	1.02E-04		7.31E+01		1.14E+06
9401	1.86E-04	3.17E-04		2.12E+02		1.14E+06
9402	1.04E-04	1.28E-04		1.48E+02		1.42E+06
9403	9.40E-05	1.82E-04		1.07E+02		1.14E+06
9404	3.50E-05	7.63E-05		4.00E+01		1.14E+06
9405	5.40E-05	6.30E-05		7.71E+01		1.43E+06
9406	5.56E-05	1.44E-04		6.35E+01		1.14E+06
	6.79E-05		2.51E+03	8.47E+01	3.13E+12	1.25E+06
93 sum				8.77E+02		
9394 sum				1.52E+03		
Township Sewage						
9301	3.85E-05	9.27E-05		5.66E-01		1.47E+04
9302	1.24E-05	3.30E-05		2.28E-01		1.84E+04
9303	4.23E-05	9.66E-05		6.22E-01		1.47E+04
9304	1.53E-05	1.76E-05		1.96E-01		1.28E+04
9305	1.64E-05	2.52E-05		3.02E-01		1.84E+04
9306	3.09E-05	6.75E-05		4.54E-01		1.47E+04
9307	5.32E-05	8.59E-05		7.82E-01		1.47E+04
9308	5.64E-05	8.46E-05		1.03E+00		1.83E+04
9309	3.98E-05	7.69E-05		5.85E-01		1.47E+04
9310	4.59E-05	1.48E-04		6.75E-01		1.47E+04
9311	3.15E-05	9.00E-05		5.80E-01		1.84E+04
9312	9.31E-06	1.70E-05		1.37E-01		1.47E+04

TRITIUM IN WATER (pg 2 of 3)

	Tritium Avg. µCi/ml	max conc. µCi/ml	Bq/L	Total act. Ci/mo.	Bq/mo.	Vol. (m3/mo.)
9401	3.16E-06	1.26E-05		4.64E-02		1.47E+04
9402	6.29E-06	1.58E-05		1.15E-01		1.83E+04
9403	1.37E-05	2.39E-05		2.01E-01		1.47E+04
9404	1.79E-05	3.06E-05		2.36E-01		1.32E+04
9405	7.92E-06	1.56E-05		1.45E-01		1.83E+04
9406	3.10E-05	4.27E-05		4.56E-01		1.47E+04
[illegible]	2.62E-05		9.70E+02	4.09E-01	1.51E+10	1.56E+04
93 sum				6.16E+00		
9394 sum				7.36E+00		
RBSW Effluent						
9301	1.46E-04	2.00E-04		3.93E+03		2.69E+07
9302	4.52E-06	8.17E-06		1.51E+02		3.34E+07
9303	5.36E-06	8.50E-06		1.44E+02		2.69E+07
9304	1.06E-05	1.89E-05		2.86E+02		2.70E+07
9305	8.92E-06	1.25E-05		2.99E+02		3.35E+07
9306	1.90E-05	3.88E-05		5.11E+02		2.69E+07
9307	1.71E-05	2.90E-05		4.59E+02		2.68E+07
9308	1.44E-06	7.20E-06		4.84E+01		3.36E+07
9309	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9310	4.54E-06	1.81E-05		1.22E+02		2.69E+07
9311	1.39E-06	6.97E-06		4.68E+01		3.37E+07
9312	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9401	5.88E-06	1.59E-05		1.58E+02		2.69E+07
9402	1.85E-05	4.85E-05		6.23E+02		3.37E+07
9403	1.12E-05	2.50E-05		3.02E+02		2.70E+07
9404	1.03E-05	2.37E-05		2.77E+02		2.69E+07
9405	2.79E-06	8.37E-06		9.38E+01		3.36E+07
9406	1.72E-06	6.90E-06		4.64E+01		2.70E+07
avg	1.50E-05		5.53E+02	4.17E+02	1.54E+13	2.78E+07
93 sum				6.00E+03		
9394sum				7.50E+03		
AIFB Effluent						
9301	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9302	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9303	6.19E-06	2.47E-05		1.07E+00		1.73E+05
9304	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9305	1.72E-06	8.64E-06		3.83E-01		2.23E+05
9306	4.55E-06	1.82E-05		2.45E+00		5.38E+05
9307	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9308	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9309	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9310	4.44E-06	1.77E-05		5.89E-01		1.33E+05
9311	2.05E-06	1.02E-05		4.41E-01		2.15E+05
9312	4.37E-06	1.74E-05		7.20E-01		1.65E+05
9401	3.93E-06	1.57E-05		6.58E-01		1.67E+05
9402	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9403	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9404	3.71E-06	1.48E-05		6.15E-01		1.66E+05
9405	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9406	2.49E-06	9.98E-06		4.41E-01		1.77E+05
avg	1.86E-06		6.88E+01	4.09E-01	1.51E+10	2.20E+05
93 sum				5.65E+00		
9394 sum				7.37E+00		
Sulzer A SW Effluent						
9301	5.50E-05	7.82E-05		2.05E+00		3.73E+04
9302	6.70E-05	7.70E-05		3.12E+00		4.66E+04
9303	1.13E-04	1.93E-04		4.21E+00		3.73E+04
9304	3.59E-05	5.23E-05		1.34E+00		3.73E+04
9305	5.52E-05	7.04E-05		2.57E+00		4.66E+04
9306	6.13E-05	8.36E-05		2.28E+00		3.72E+04
9307	7.21E-05	1.18E-04		2.68E+00		3.72E+04
9308	5.36E-05	1.07E-04		2.49E+00		4.65E+04
9309	5.36E-05	8.37E-05		1.99E+00		3.71E+04
9310	6.91E-05	1.12E-04		2.57E+00		3.72E+04
9311	7.00E-05	1.28E-04		3.26E+00		4.66E+04
9312	1.17E-04	2.48E-04		4.39E+00		3.75E+04
9401	1.96E-04	4.04E-04		7.31E+00		3.73E+04
9402	7.41E-05	2.07E-04		3.45E+00		4.66E+04
9403	6.33E-05	1.06E-04		2.36E+00		3.73E+04
9404	1.55E-04	5.39E-04		5.80E+00		3.74E+04
9405	4.78E-05	7.08E-05		2.22E+00		4.64E+04
9406	2.56E-05	3.69E-05		9.56E-01		3.73E+04
avg	7.69E-05		2.85E+03	3.06E+00	1.13E+11	3.98E+04
93 sum				3.30E+01		
9394 sum				5.50E+01		
Sulzer B SW Effluent						
9301	1.52E-06	6.08E-06		2.97E-01		1.95E+05
9302	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9303	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9304	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9305	2.63E-06	6.95E-06		6.44E-01		2.45E+05
9306	2.05E-06	8.20E-06		4.10E-01		2.00E+05
9307	1.56E-06	6.26E-06		3.06E-01		1.96E+05

TRITIUM IN WATER (pg 3 of 5)

9309	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9310	3.68E-05	1.00E-04		7.20E+00		1.96E+05
9311	1.69E-05	3.61E-05		4.15E+00		2.46E+05
9312	1.84E-05	2.68E-05		3.59E+00		1.95E+05
9401	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9402	4.24E-06	1.50E-05		1.03E+00		2.43E+05
9403	4.16E-05	1.66E-04		8.15E+00		1.96E+05
9404	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9405	1.68E-06	8.42E-06		4.11E-01		2.45E+05
9406	0.00E+00	0.00E+00		0.00E+00		0.00E+00
avg	7.61E-06		2.82E+02	1.59E+00	5.87E+10	2.08E+05
93 sum				1.89E+01		
9394 sum				2.85E+01		
Total 93 sum				1.39E+04		
Total 9394sum				2.09E+04		

Pickering B NGS ALW 9301 to 9406

	Tritium Avg uCi/ml	max con uCi/ml	Bq/L	Total Act Ci	Bq/mo.	Vol m3/mth
CCW effluent						
9301	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9302	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9303	4.28E-07	7.70E-05		7.45E+01		1.74E+08
9304	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9305	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9306	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9307	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9308	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9309	1.81E-07	7.37E-06		3.92E+01		2.17E+08
9310	2.40E-08	3.37E-06		5.57E+00		2.32E+08
9311	1.51E-08	2.27E-06		4.38E+00		2.90E+08
9312	1.78E-07	7.88E-06		3.59E+01		2.02E+08
9401	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9402	3.62E-08	1.04E-05		2.62E+00		7.24E+07
9403	2.07E-08	2.43E-06		4.81E+00		2.32E+08
9404	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9405	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9406	0.00E+00	0.00E+00		0.00E+00		0.00E+00
avg	4.91E-08	6.15E-06	1.82E+00	9.28E+00	3.43E+11	1.89E+08
93 sum				1.60E+02		
9394 sum				1.67E+02		
RBSW Effluent						
9301	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9302	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9303	3.87E-06	9.21E-06		1.04E+02		2.69E+07
9304	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9305	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9306	2.99E-06	1.19E-05		8.04E+01		2.69E+07
9307	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9308	1.25E-06	6.27E-06		4.21E+01		3.37E+07
9309	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9310	2.06E-05	4.94E-05		5.54E+02		2.69E+07
9311	1.73E-06	8.66E-06		5.82E+01		3.36E+07
9312	1.51E-06	6.04E-06		4.06E+01		2.69E+07
9401	1.47E-06	5.88E-06		3.95E+01		2.69E+07
9402	8.59E-06	1.65E-05		2.88E+02		3.35E+07
9403	6.35E-06	1.08E-05		1.70E+02		2.68E+07
9404	1.28E-05	3.51E-05		3.44E+02		2.69E+07
9405	0.00E+00	0.00E+00		0.00E+00		0.00E+00
9406	0.00E+00	0.00E+00		0.00E+00		0.00E+00
avg	3.40E-06		1.26E+02	9.56E+01	3.54E+12	2.81E+07
93 sum				8.79E+02		
9394 sum				1.72E+03		
Total Grand 93 sum				1.49E+04		
Total Grand 9394 sum				2.28E+04		

SUMMARY OF TOTAL TRITIUM EMISSIONS FROM PICKERING A+B FOR JAN 1991 to JUN 1993.

Total on annual report (1993)			1.44E+04		
CCW %	2.36E+14	6.37E+03	4.27E+01	4.01E+01	43%
RBSW	2.54E+14	6.88E+03	4.61E+01	4.04E+01	46%
UppB Effluent	2.81E+13	7.59E+02	5.08E+00	1.25E+01	5%
UPP A Effluent	3.25E+13	8.77E+02	5.88E+00	6.68E+00	6%
Sewage	2.28E+11	6.16E+00	4.12E-02	4.08E-01	
AIFB	2.09E+11	5.65E+00	3.79E-02	6.01E-01	
Sulzer A	1.22E+12	3.30E+01	2.21E-01	2.41E-01	
Sulzer B	7.01E+11	1.89E+01	1.27E-01	1.25E-01	
Total	5.53E+14		1.00E+02	1.01E+02	
	Bq/a	Ci/a	% of total 93	% of total 9394	

(!)

TRITIUM IN WATER

Bruce A 93 weekly report Tritium Releases	ALW Ci/wk		Bruce A 92 weekly report			Bruce A 91 weekly report					
930106	272			252			329	BL			
930113	894			251			509	BL			
930120	283		920122	1389			245	4 BL			
930127	343		920129	1038			358				
930203	239			773			288	4 BL			
930210	622			238			724				
930217	256			185			670	4 BL			
930224	945			595			252	4 BL			
930303	268			357		910306	2369	4 BL			
930310	224			507		910313	1475				
930317	33			568			646				
930324	602			374		910327	2114				
930331	319			451			327				
930407	328	1BL		384			267				
930414	332	1BL		372			223				
930421	489	1BL		325			684				
930428	659	1BL		449			273	BL			
930505	1221	1BL		268			702				
930512	359	1BL		353			467	BL			
930519	784	1BL		518		910522	1123	1 BL			
930526	228	1BL		548		910529	2186	1 BL			
930602	824	1BL		403		910605	2078	1 BL			
930609	663	1BL		581			386				
930616	86	1BL		689			342				
930623	275	BL		451			543				
930630	6305	BL		520			375				
930707	4457	BL		772			207				
930714	715	BL		535			863	2 BL			
930721	723	1 BL	920722	1252			317	1,2 BL			
930728	568	1 BL		369			287	1,2 BL			
930804	906	1 BL		453		910807	1773	1,2,4BL			
930811	587	1,3 BL	920812	1540		910814	4613	1,2,4BL			
930818	907	1,3 BL		914		910828	9547	1,2,4BL			
930825	588	1 BL		355		910904	3558	1,4 BL	13320		
930901	892	1 BL		712		910911	3806	1,4 BL			
930908	945	1 BL		439		910918	5286	BL			
930915	832	1,3,4 BL		320			670				
930922	832	1,3,4 BL		884		911002	1353	BL	14254	13838	5.1E+14
930929	804	1,3,4 BL		609		911009	4724	BL			
931006	964	1,3,4 BL		461		911016	2768	1 BL			
931013	689	1,3,4 BL		335		911023	2314				
931020	743	1,3,4 BL		570		911030	3095				
931027	801			376		911106	2266	1 BL	9573		
931103	904	1 BL		473		911113	4949	1 BL			
931110	1445	1, 3 boiler leak	921111	2163		911120	2074	1 BL			
931117	163	1, 3 boiler leak	921118	2503			284				
931124	139	1, 3 boiler leak	921125	2757		911204	1292				
931201	649	1, 3 boiler leak	921202	2927	12942	911211	1014				
931208	1015	1, 3 boiler leak	921209	3973		911218	1014				
931215	158	1, 3 boiler leak	921216	5655			265				
931222	323			387			326				
931229	868	1 BL		619			252				
93 @ sum	40470	3372.5	92 @ sum	45192	3766		78872	6572.7			

Estimation	1993	1992	1991		Average over three years	
Regular discharge ALW (Ci/a)	28795	24756	21662		25071	
Ci/mth	2400	2063	1805		2089	7.7E+13 Bq/mth
Irregular discharge (Ci/a)	11674	20436	54116		28742	
Ci/mth	973	1703	4510	1.7E+14	2395	8.9E+13 Bq/mth
	4E+13					

TRITIUM IN WATER

Bruce B weekly report	Tritium Releases Liquid Effluent Ci/wk		Bruce B 92 Tritium Rel		Bruce B 91 tritium release	
					172	
930106	280		106		190	
930113	215		116		220	
930120	91		46		108	
930127	370		43.6		759	
930203	395		54		902	
930210	321		54		183	
930217	741		91		122	
930224	329		96		212	
930303	108		86		861	
930310	135		128		720	
930317	115		70		102	
930324	266		90		102	
930331	142		90		237	
930407	207		92		440	
930414	334		124		152	
930421	283		536		265	
930428	168		834		120	
930505	222		408		132	
930512	388		638		159	
930519	194		110		193	
930526	206		112		67	
930602	215		105		214	
930609	275		259		213	
930616	187		208		162	
930623	268		133		389	
930630	244		261		1420	
930707	181		342		493	
930714	110		290		291	
930721	335		207		322	
930728	330		183		199	
930804	348		325		149	
930811	353		290		367	
930818	374		362		267	
930825	290		418		167	
930901	257		414		170	
930908	280		380		445	
930915	282		279		648	
930922	391		303		317	
930929	347		349		99	
931006	271		283		124	
931013	383		223		376	
931020	214		159		413	
931027	1940	4910	148		285	
931103	1231		187		399	
931110	1254		134		77	
931117	485		174		314	
931124	403		188		148	
931201	345		136		289	
931208	146		91		215	
931215	198		47		99	
931222	162		193		95	
931229	175		146		152	
@sum	17784	1482 Ci/mth	11141.6	928.5	15564.2	1297.0 Ci/mth

Estimation	1993	1992	1991 average		
Regular discharge ALW	14176	11141	15564	13627	
Ci/mth	1181	928	1297	1136	4.2E+13 Bq/mth.
Irregular discharge	3607				
Ci/mth	301				
	1.1E+13				
3729	1.4E+14 Maximum				

TRITIUM IN WATER

Darlington Tritium Release

	tritium in liquid emission				
	ALW	CCW			
9301	4.97E+01	0.00E+00			
9302	1.89E+02	0.00E+00			
9303	1.95E+02	0.00E+00			
9304	6.62E+01	0.00E+00			
9305	5.01E+01	0.00E+00			
9306	4.31E+01	3.70E-01			
9307	1.75E+02	0.00E+00			
9308	1.83E+02	0.00E+00			
9309	3.57E+01	0.00E+00			
9310	1.03E+02	0.00E+00			
9311	1.73E+02	0.00E+00			
9312	2.85E+02	0.00E+00			
@sum	1.55E+03	3.70E-01	1548.2	129.01	Ci/mth

<<

TABLE 10

SUMMARY OF TRITIUM EMISSIONS TO WATER

TBq/y

	1993 TOTAL	1993 % OF TOTAL	1992 TOTAL	1992 % OF TOTAL	1991 TOTAL	1991 % OF TOTAL
PICKERING A+B						
CCW	2.4E+02	43.1%	3.5E+02	11.6%	2.8E+02	66.2%
UPP-B	2.8E+01	5.0%	2.2E+01	0.7%	2.9E+00	0.7%
UPP-A	3.3E+01	5.9%	4.6E+01	1.5%	4.2E+00	1.0%
SEWAGE	2.3E-01	0.0%	3.0E-01	0.0%	1.2E+00	0.3%
RBSW	2.5E+02	45.6%	2.6E+03	86.0%	1.3E+02	30.6%
AIFB	2.1E-01	0.0%	8.4E-02	0.0%	2.7E-01	0.1%
SULZER-A	1.2E+00	0.2%	2.7E+00	0.1%	4.0E-01	0.1%
SULZER-B	7.0E-01	0.1%	3.4E+00	0.1%	4.8E+00	1.1%
TOTAL	5.6E+02	100.0%	3.0E+03	100.0%	4.3E+02	100.0%
BRUCE A						
REGULAR	1.1E+03	71.2%	9.2E+02	54.8%	8.0E+02	28.6%
IRREGULAR	4.3E+02	28.8%	7.6E+02	45.2%	2.0E+03	71.4%
TOTAL	1.5E+03	100.0%	1.7E+03	100.0%	2.8E+03	100.0%
BRUCE B						
REGULAR	5.3E+02	79.7%	4.1E+02	100.0%	5.8E+02	100.0%
IRREGULAR	1.3E+02	20.3%				
TOTAL	6.6E+02	100.0%	4.1E+02	100.0%	5.8E+02	100.0%
DARLINGTON						
TOTAL	5.7E+01	100.0%				

TABLE 11

IMPACT OF APPLYING 5E-6 OR 1E-6 RISK LIMITS TO ALL ONTARIO HYDRO RADIOACTIVE EMISSIONS

BASED ONLY ON 1993 DATA

Radionuclide/ Emission Pathway	(S)ingle or (M)ultiple Pathway	Emission Reduction Factor Required for Risk = 5E-6			Emission Reduction Factor Required for Risk = 1E-6		
		DNGS	PNGS	BNPD	DNGS	PNGS	BNPD
Noble Gas/air	S	NA	6.7	1.5	4.5	34	7
C-14/AIR	S	NA	2.2	NA	1.6	11	4
H-3/AIR	S	NA	1.8	1.2	NA	9	6
H-3/WATER	S	NA	NA	NA	NA	NA	2.8
PARTICULATE/AIR	S	NA	NA	NA	NA	NA	1.1
PARTICULATE/WATER	S	NA	NA	NA	NA	NA	1.2
Noble Gas	"M"	NA	6.7	1.5	4.6	34	7
C-14	M	NA	2.2	NA	2.2	11	4.4
H-3	M	NA	2.3	2.1	1.4	12	10.4
PARTICULATE	M	NA	NA	NA	NA	NA	2.4

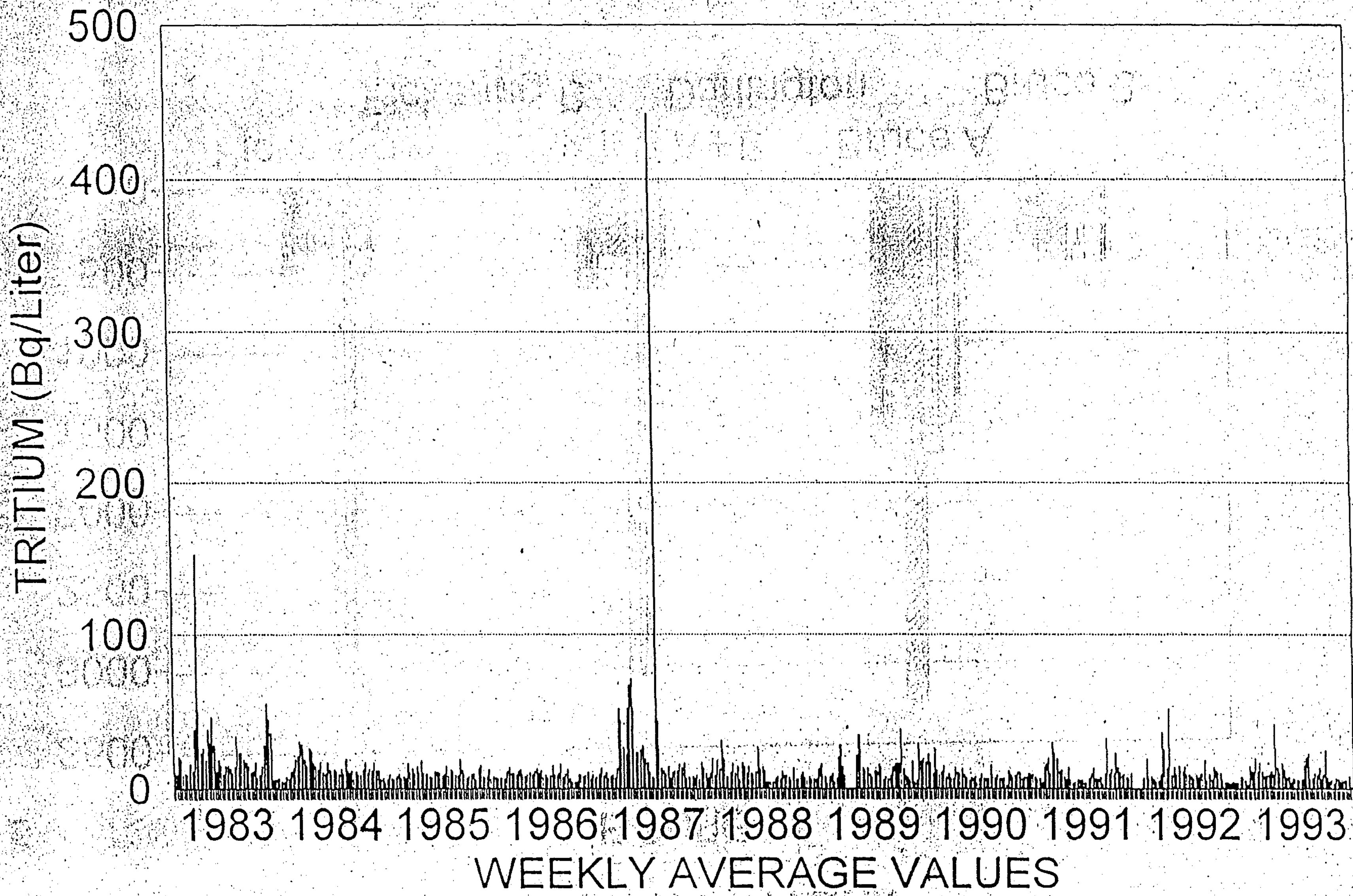
Note: The above factors assume that background radioactivity is not included.
If background is included (as required for drinking water), these factors will increase.

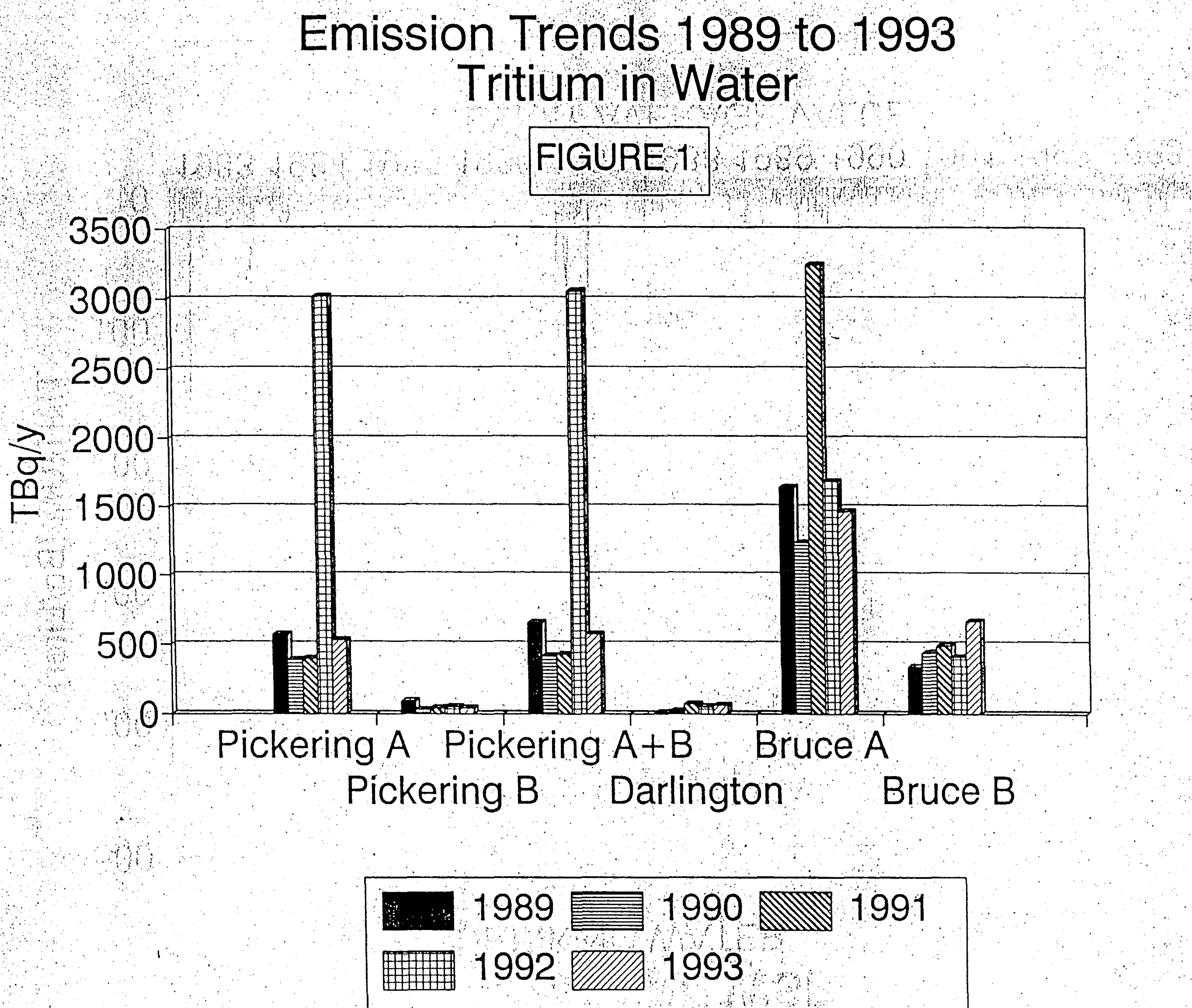
For C-14, the natural background level of about 250 Bq/kg-C already exceeds the maximum concentration that would be allowed for a lifetime risk level of 5E-6 for milk, fruits and vegetables. For the risk level of 1E-6, natural background would exceed the maximum concentrations for milk, fruits, vegetables and fish.

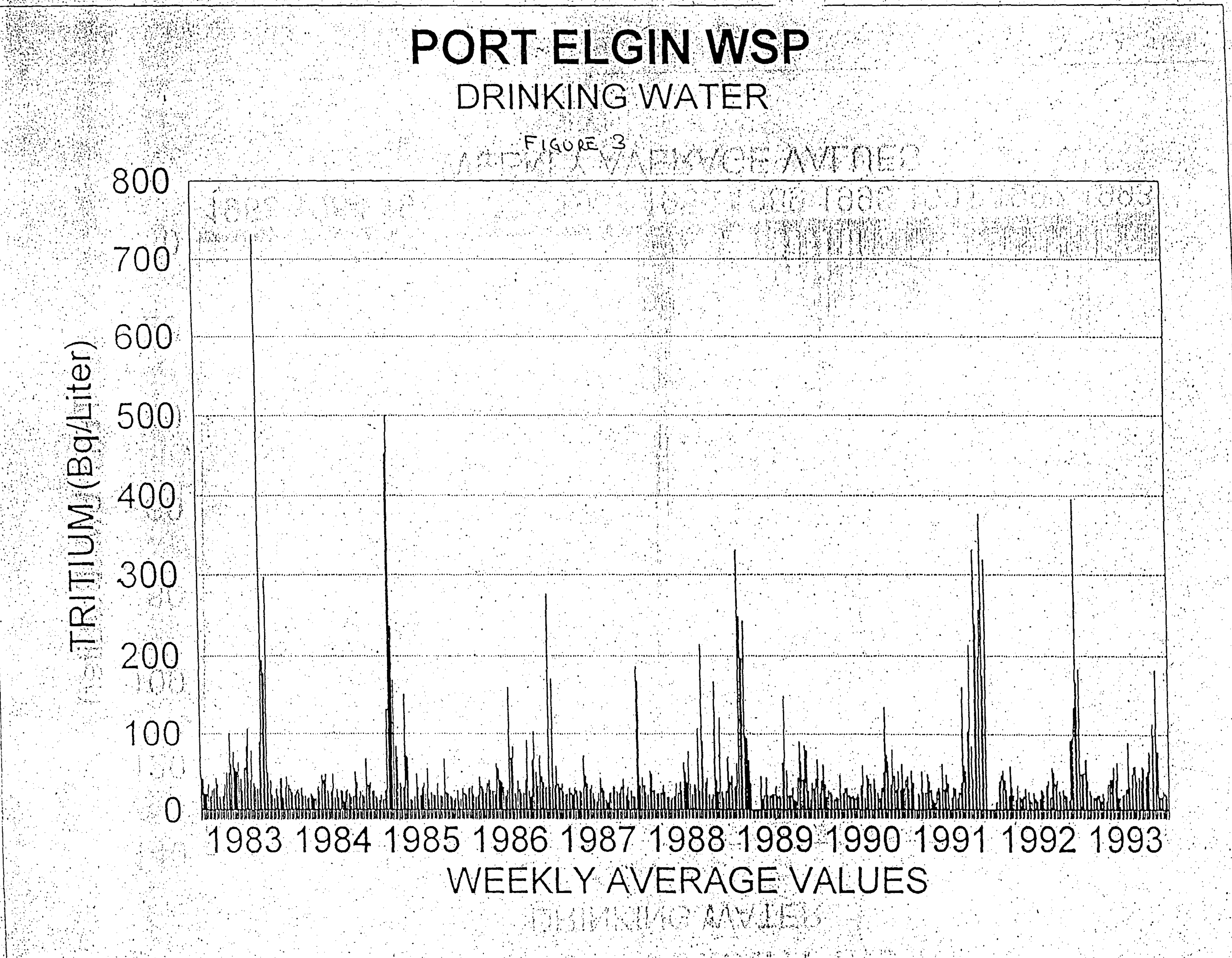
KINCARDINE WSP

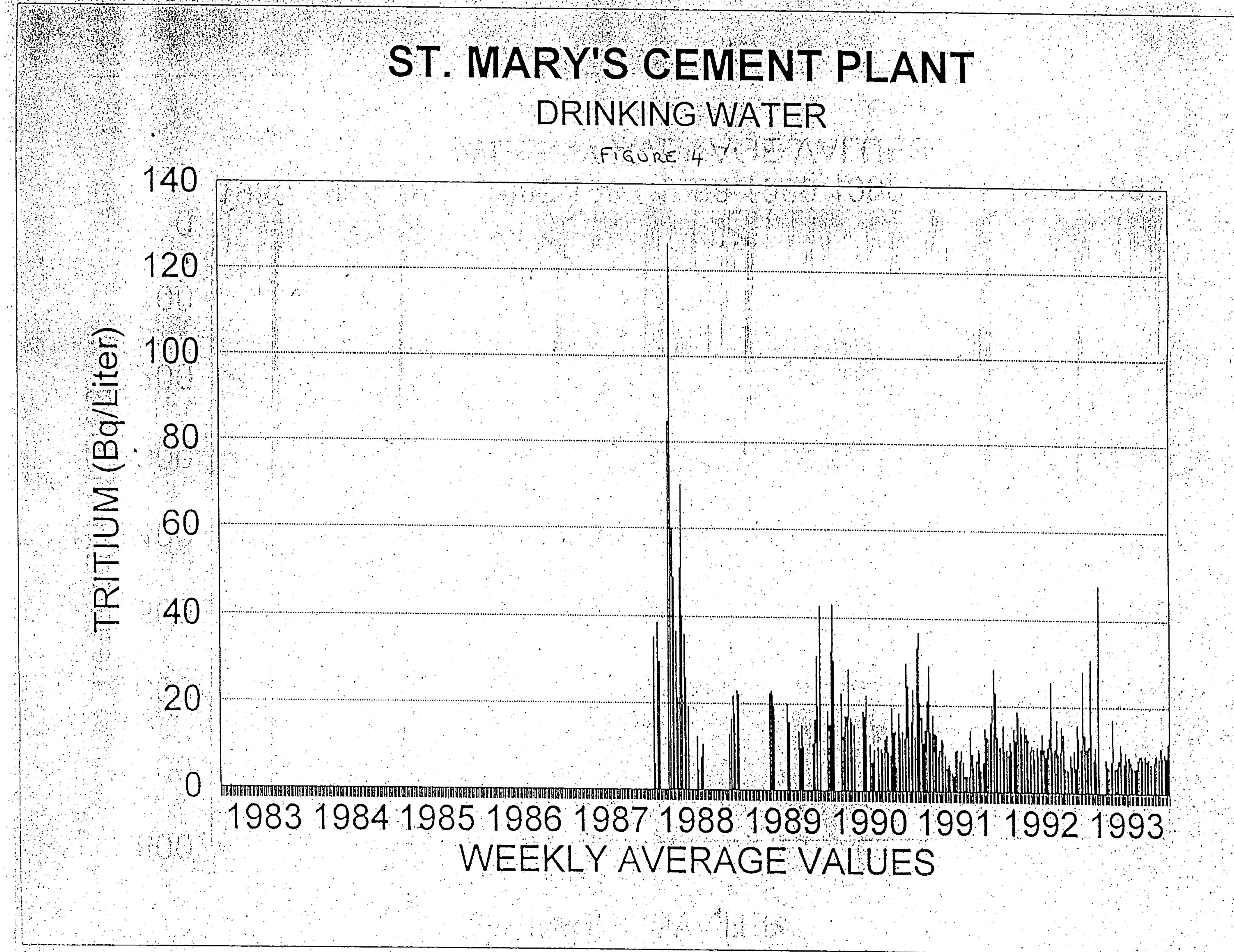
DRINKING WATER

FIGURE 2




Emission Trends 1989 to 1993
Tritium in Water
FIGURE 1
TBq/y
3500
3000
2500
2000
1500
1000
500
0
Pickering A
Pickering B
Pickering A+B
Darlington
Bruce A
Bruce B
1989
1990
1991
1992
1993

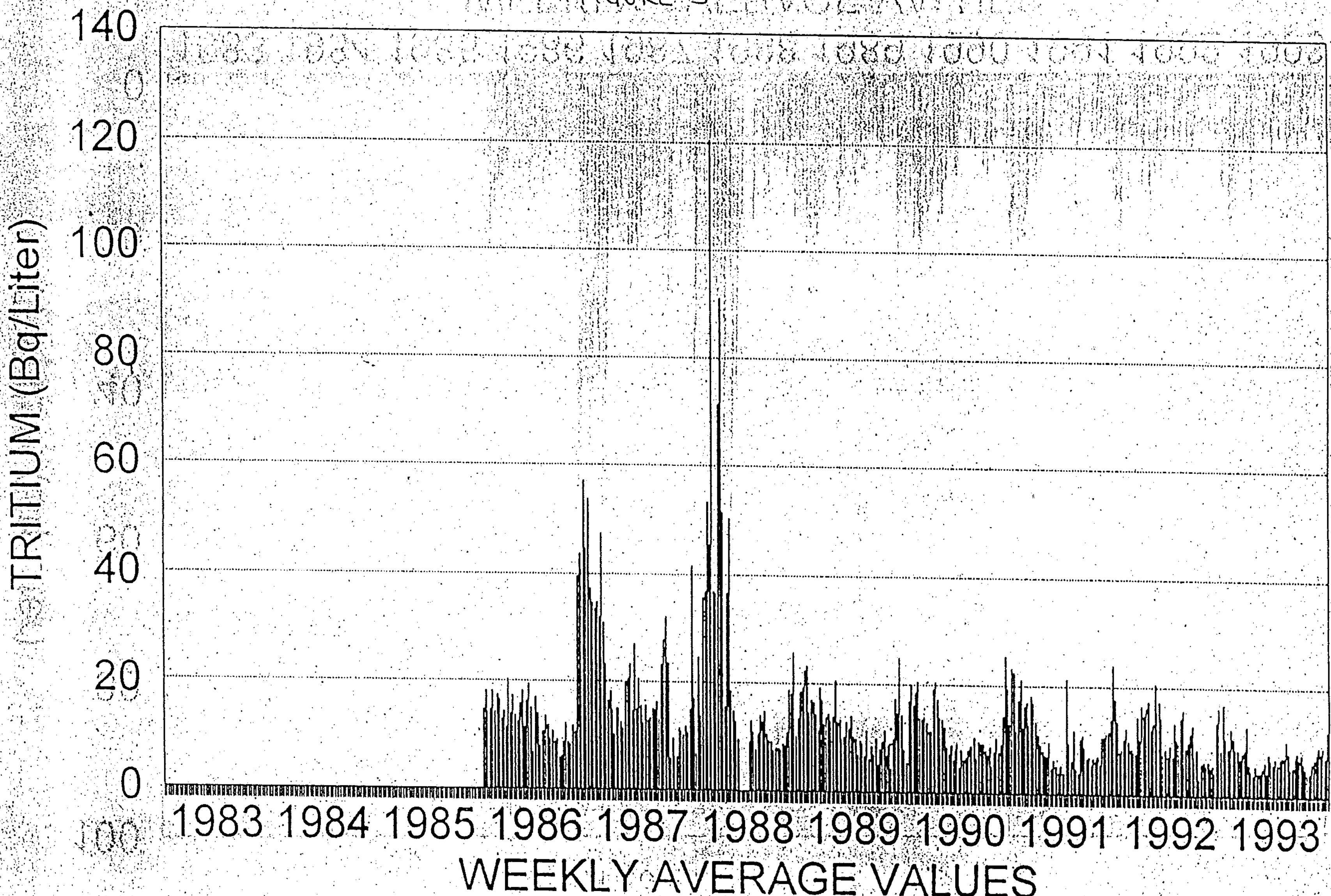

PORT ELGIN WSP
DRINKING WATER
FIGURE 3
TRITIUM (Bq/Liter)
800
700
600
500
400
300
200
100
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
WEEKLY AVERAGE VALUES


ST. MARY'S CEMENT PLANT
DRINKING WATER
FIGURE 4
TRITIUM (Bq/Liter)
140
120
100
80
60
40
20
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
WEEKLY AVERAGE VALUES

BOWMANVILLE WSP

DRINKING WATER

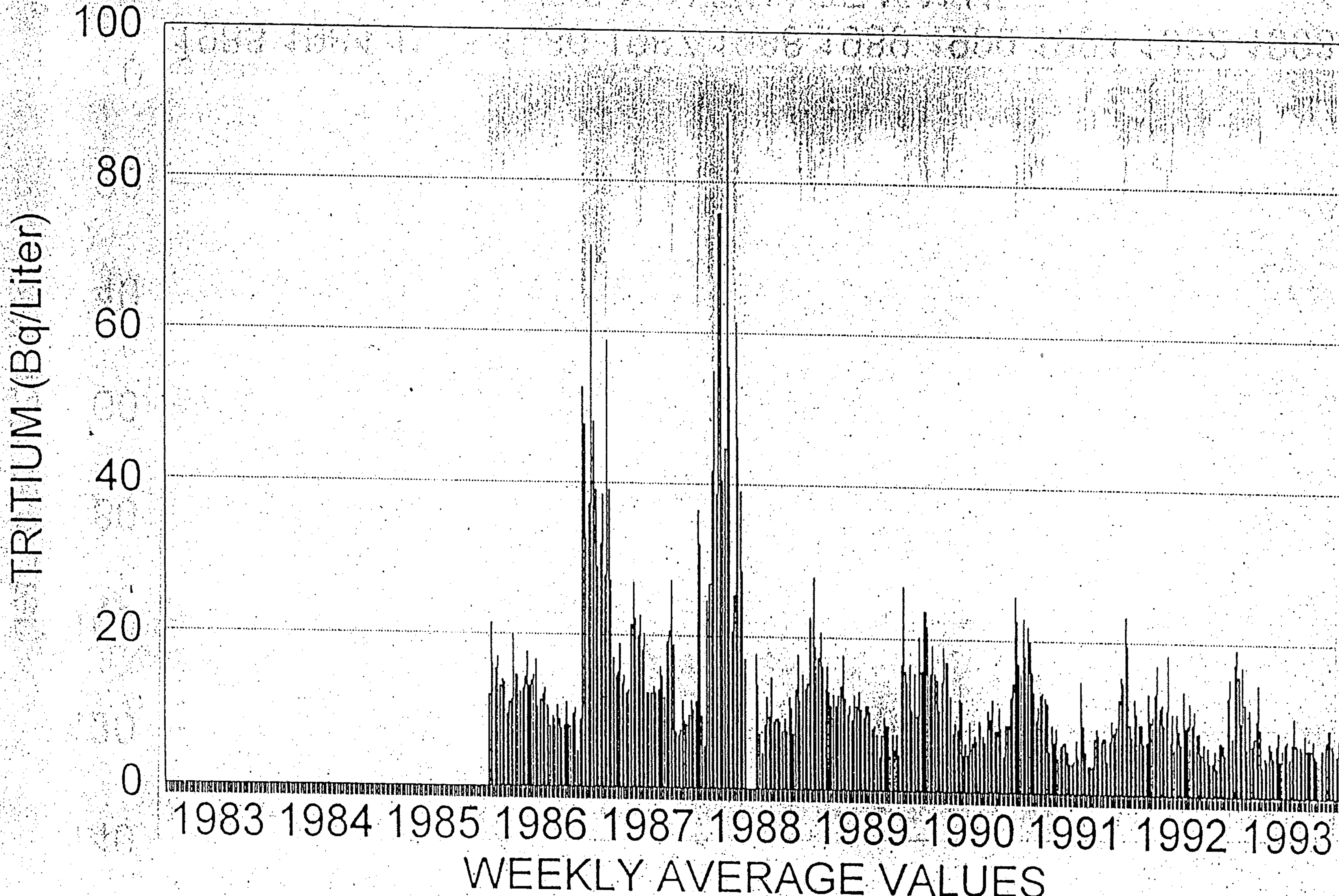
FIGURE 5

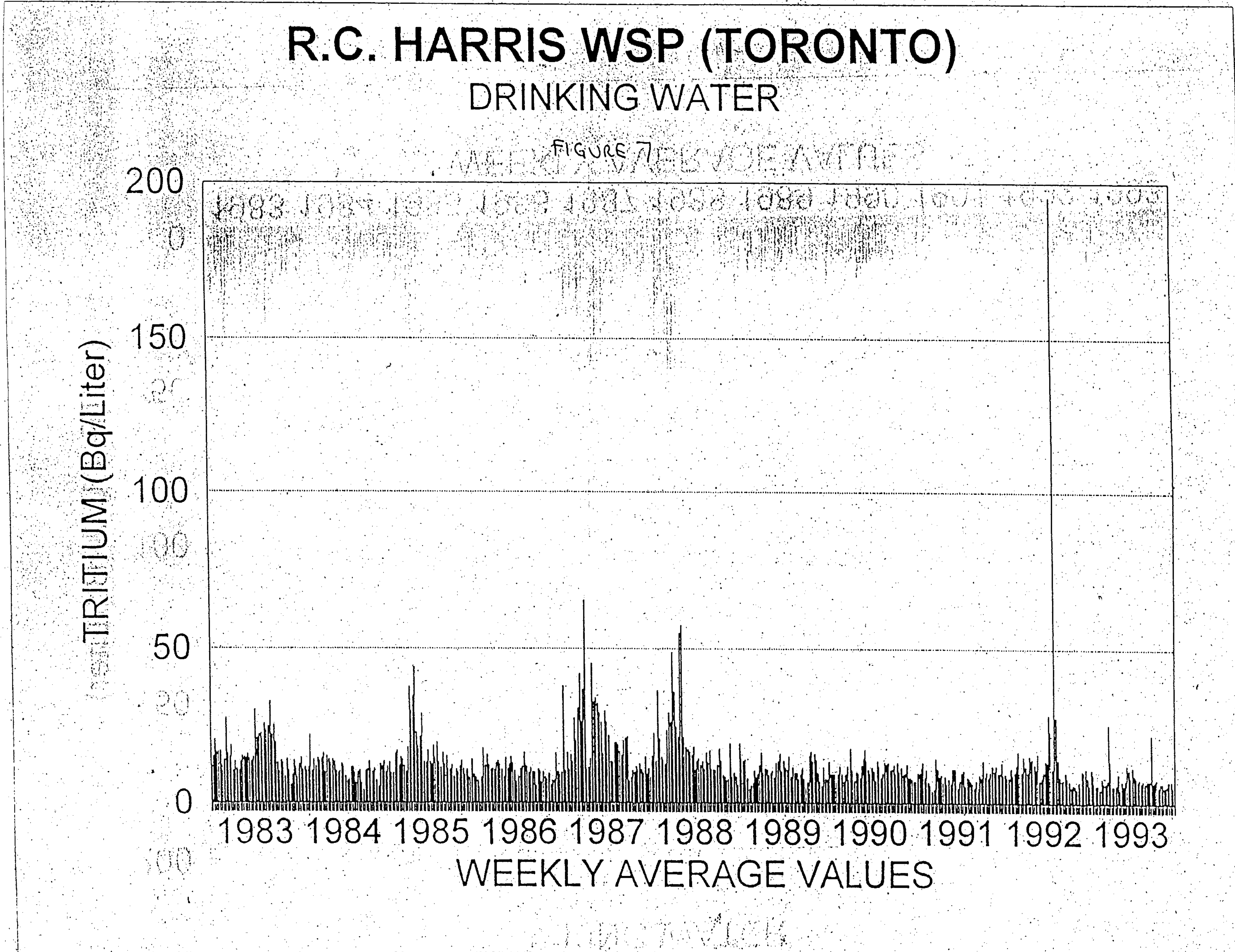


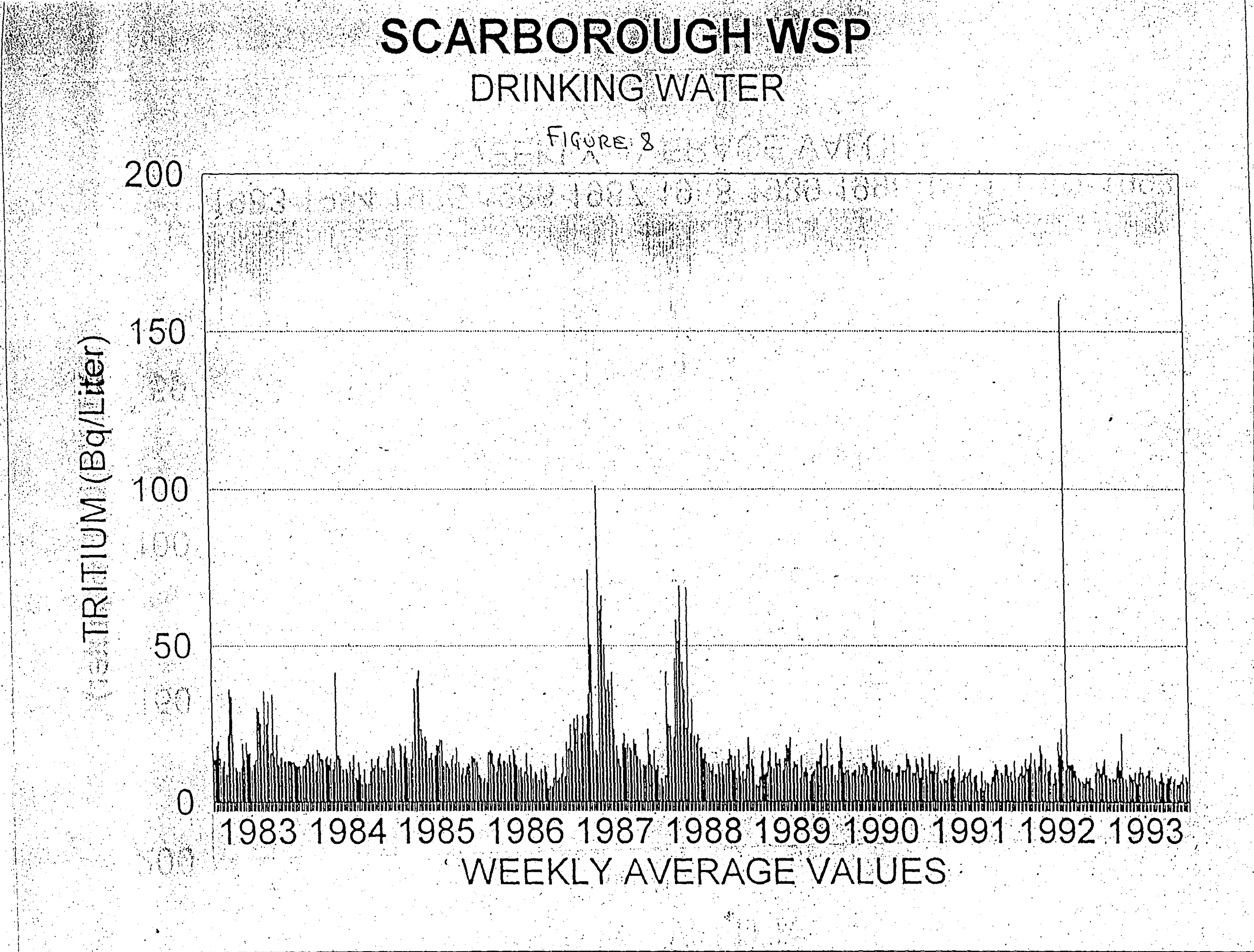
NEWCASTLE WSP

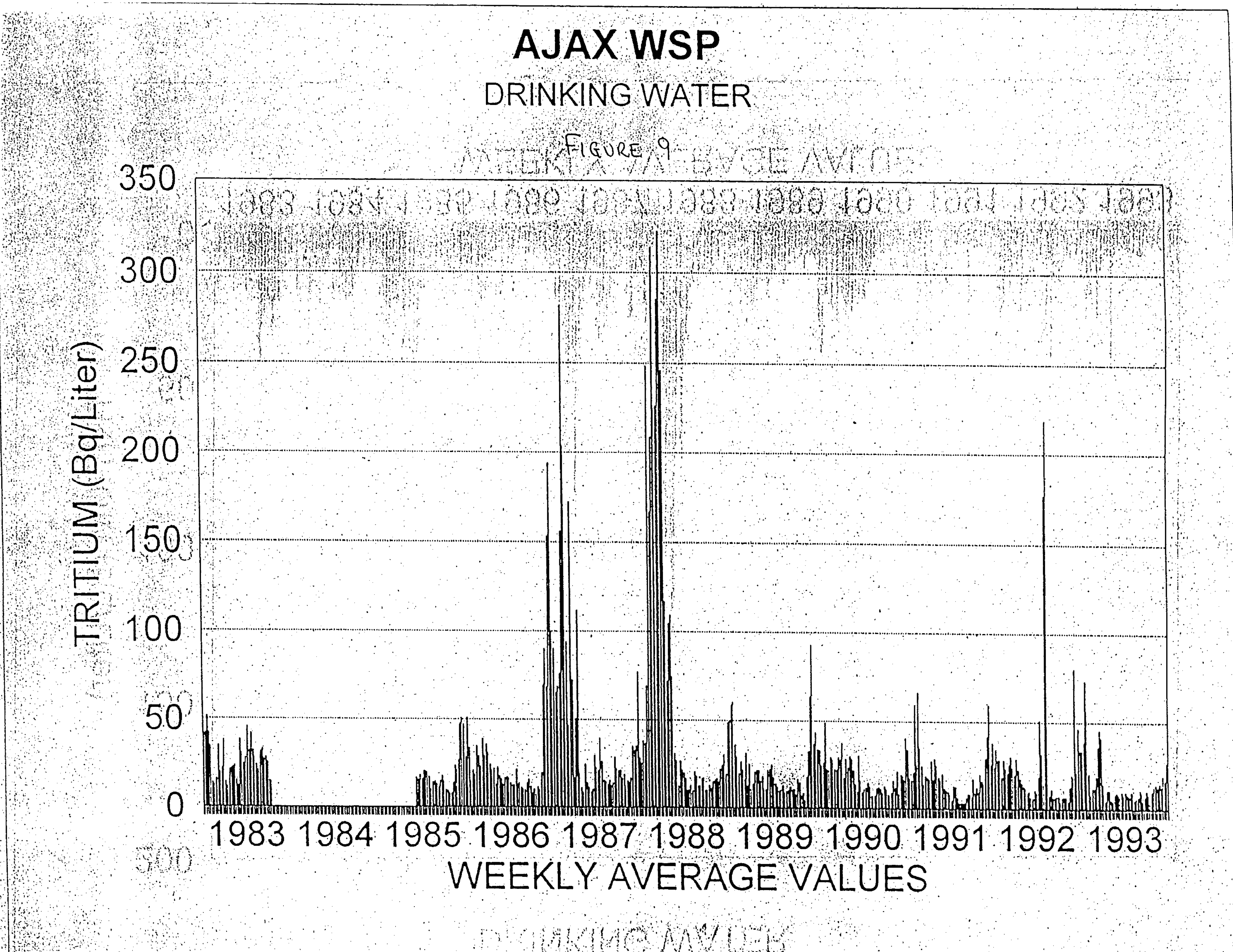
DRINKING WATER

FIGURE 6

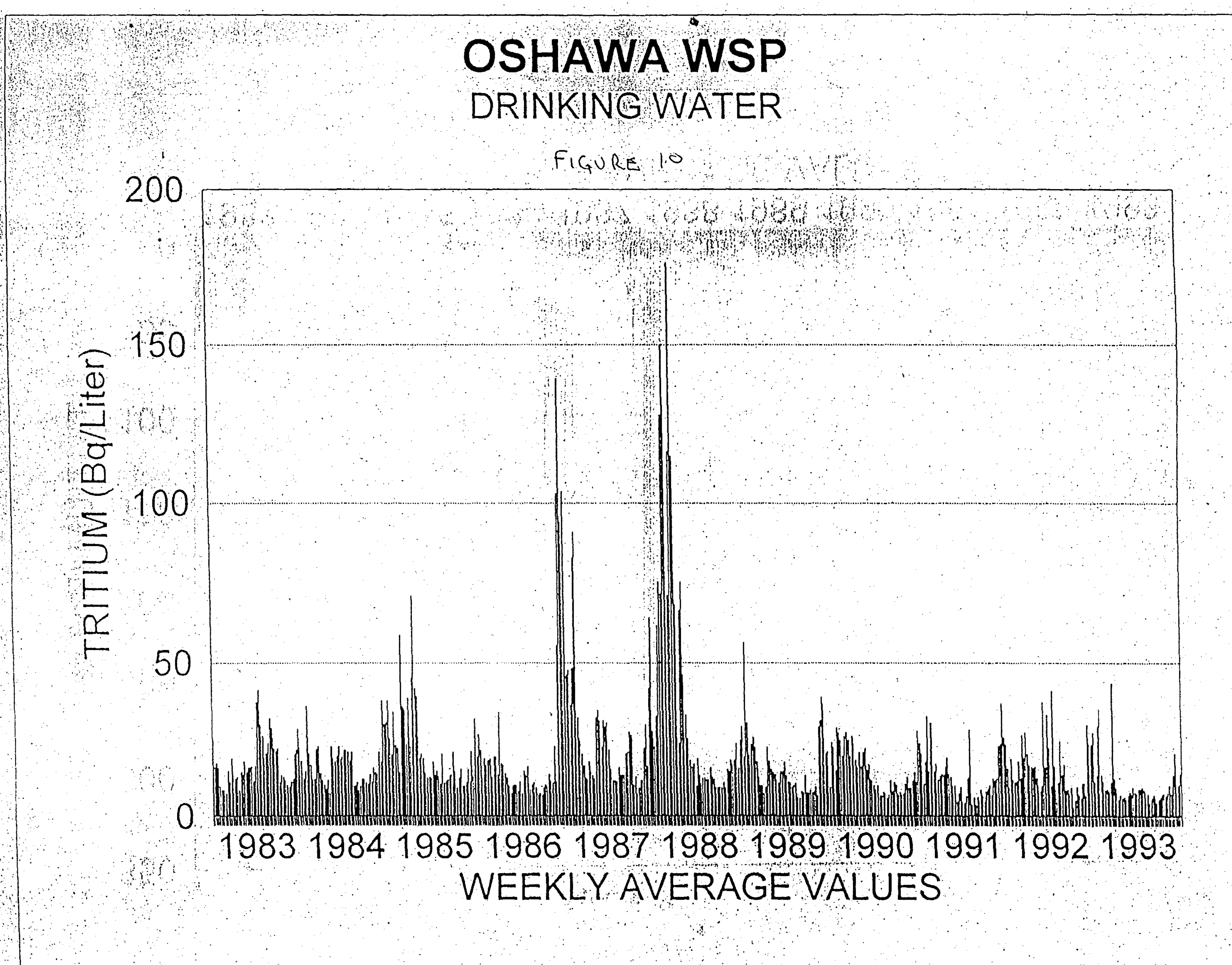



R.C. HARRIS WSP (TORONTO)
DRINKING WATER
FIGURE 7
TRITIUM (Bq/Liter)
200
150
100
50
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
WEEKLY AVERAGE VALUES


SCARBOROUGH WSP
DRINKING WATER
FIGURE 8
TRITIUM (Bq/Liter)
200
150
100
50
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
WEEKLY AVERAGE VALUES



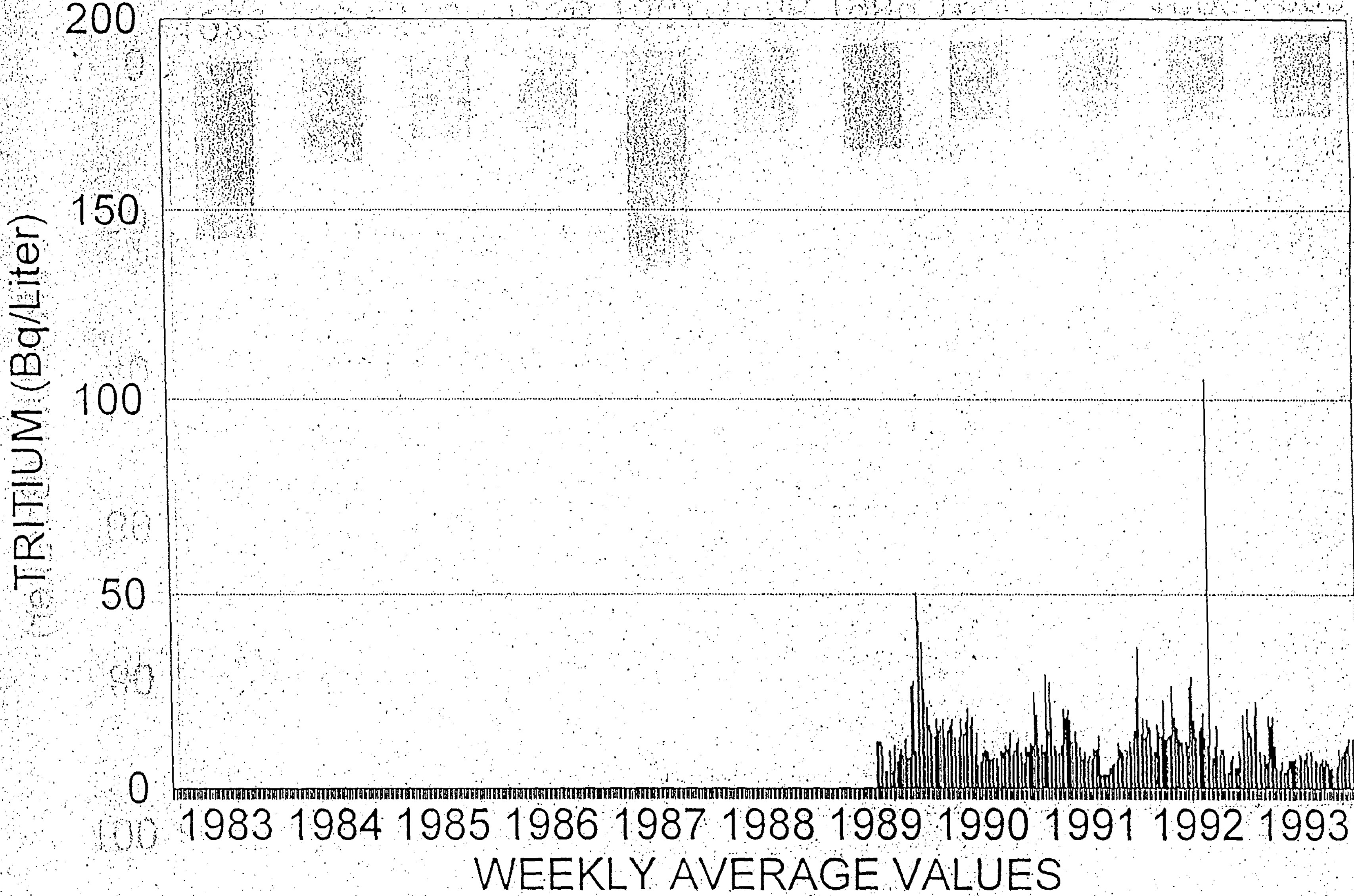
AJAX WSP
DRINKING WATER
FIGURE 9
TRITIUM (Bq/Liter)
350
300
250
200
150
100
50
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
WEEKLY AVERAGE VALUES

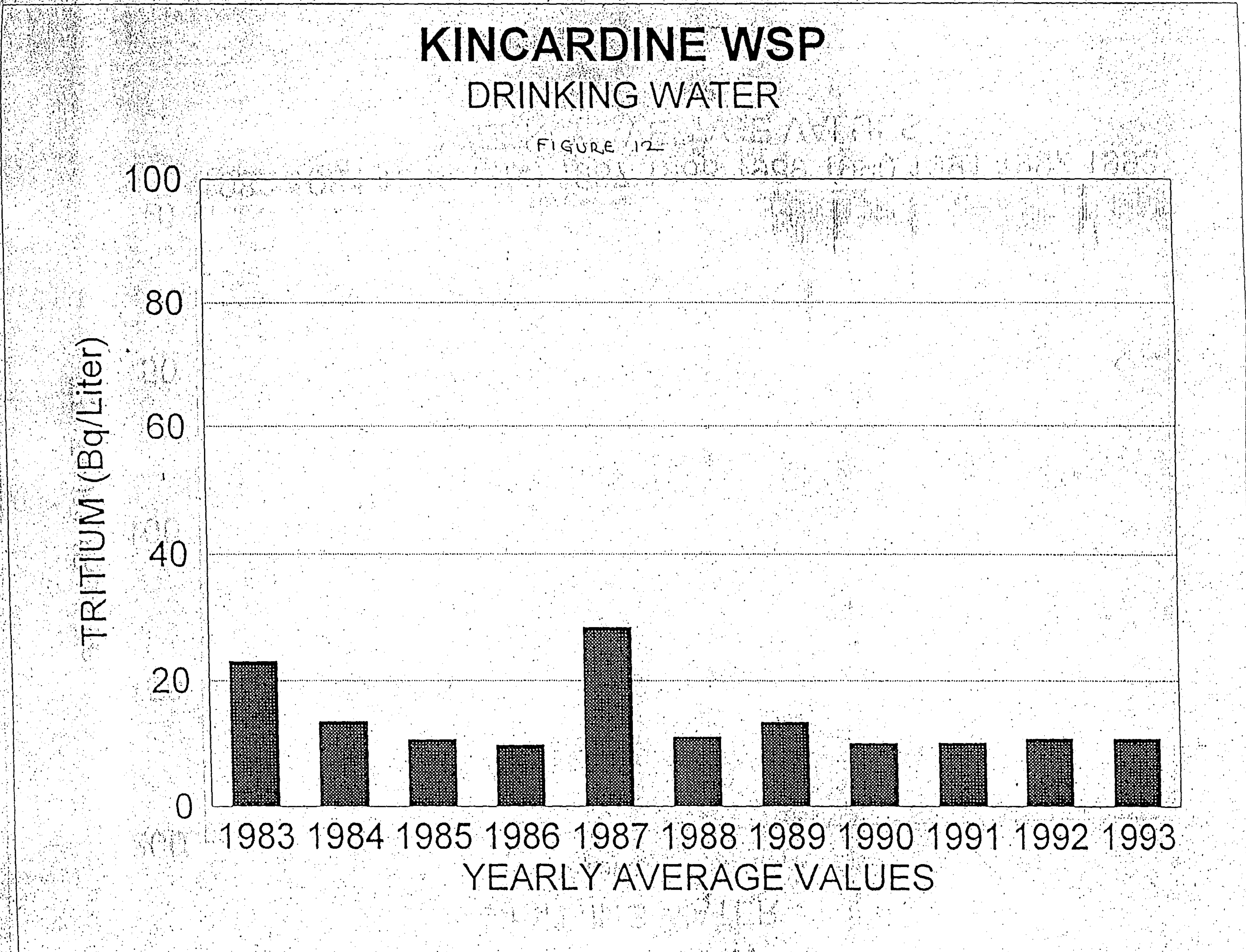

OSHAWA WSP
DRINKING WATER
FIGURE 10
200
150
100
50
0
TRITIUM (Bq/Liter)
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
WEEKLY AVERAGE VALUES

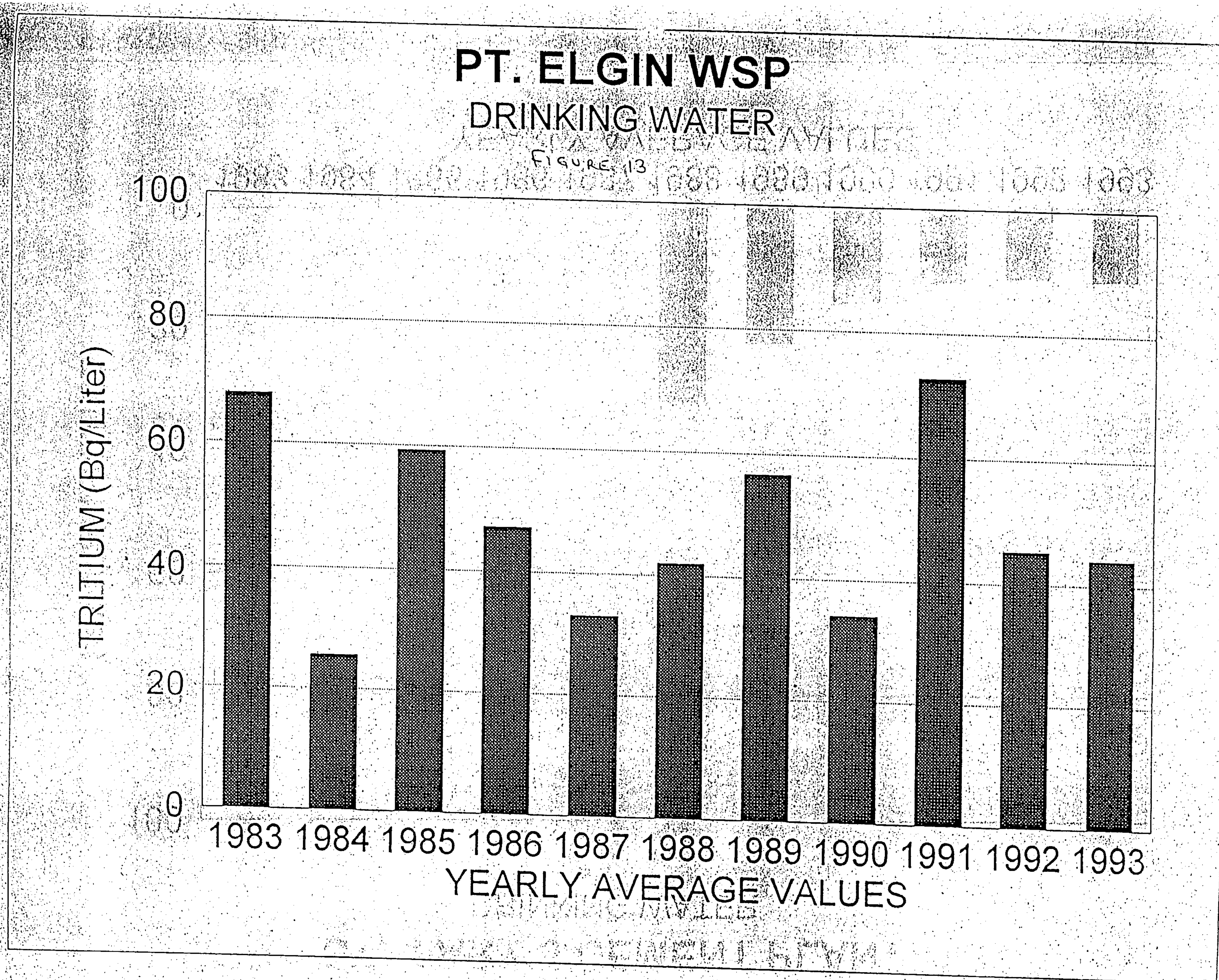
WHITBY WSP

DRINKING WATER

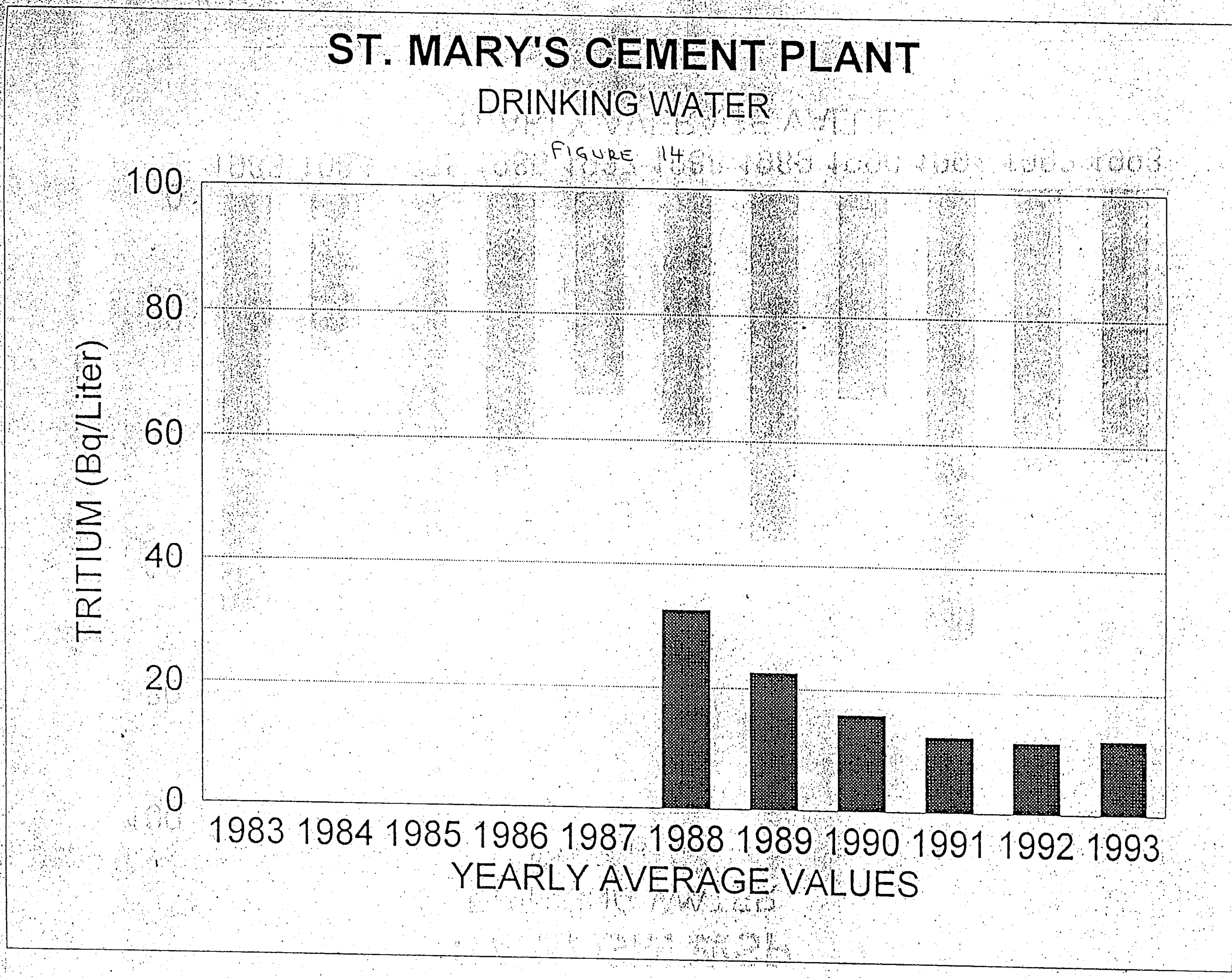
FIGURE 11

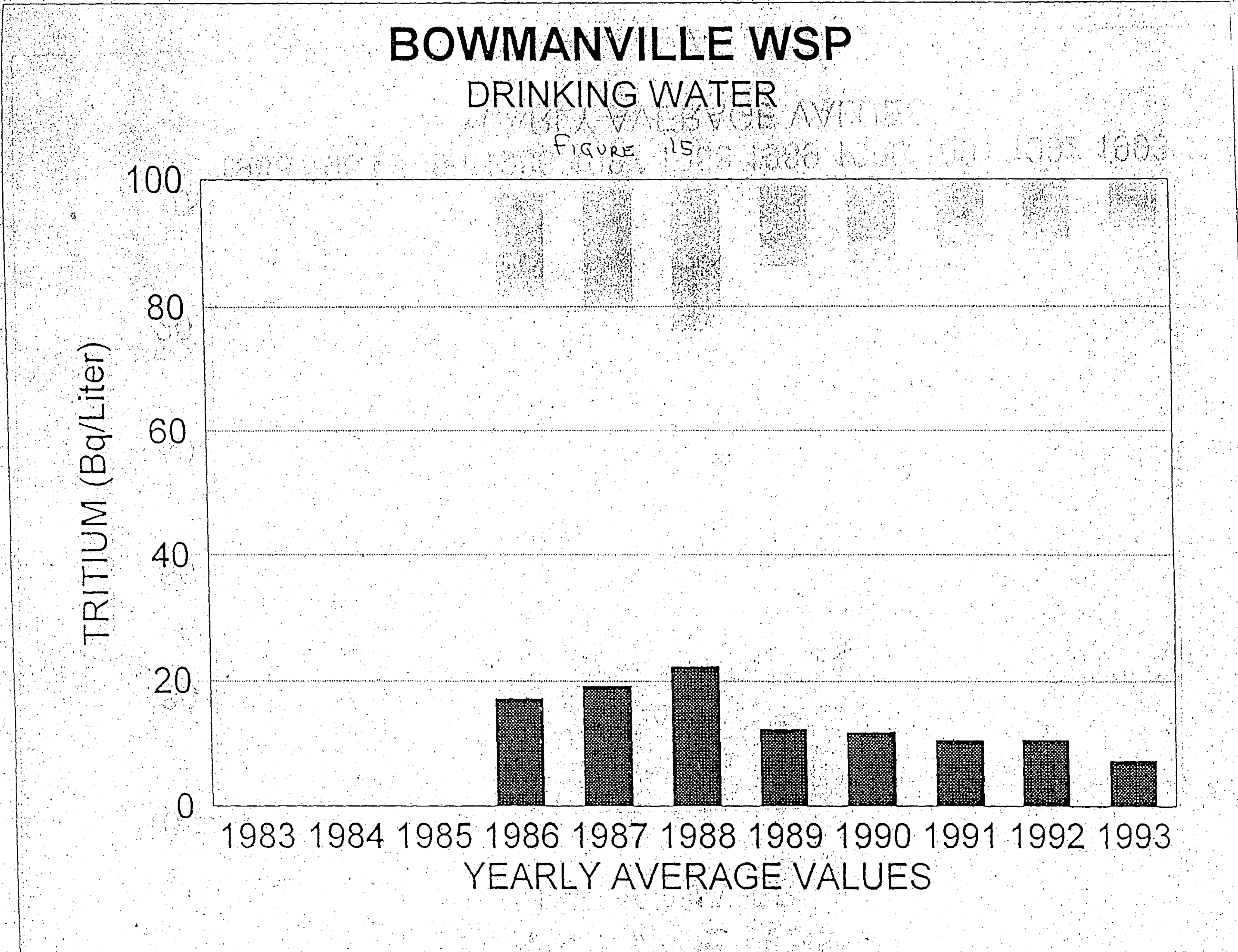


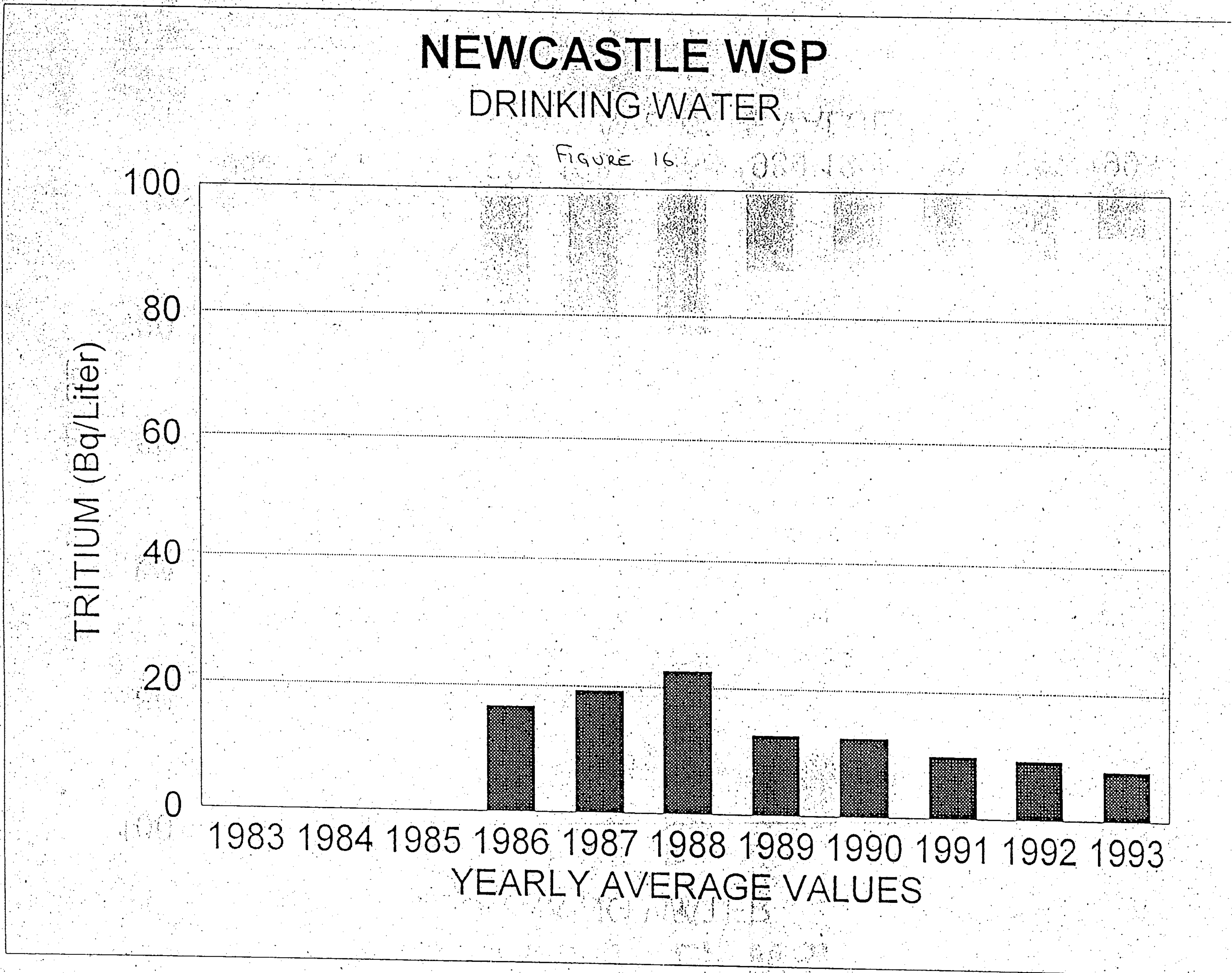

KINCARDINE WSP
DRINKING WATER
FIGURE 12
TRITIUM (Bq/Liter)
100
80
60
40
20
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
YEARLY AVERAGE VALUES



PT. ELGIN WSP
DRINKING WATER
FIGURE 13
TRITIUM (Bq/Liter)
100
80
60
40
20
0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
YEARLY AVERAGE VALUES


ST. MARY'S CEMENT PLANT
DRINKING WATER
FIGURE 14
TRITIUM (Bq/Liter)
100
80
60
40
20
0
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
YEARLY AVERAGE VALUES

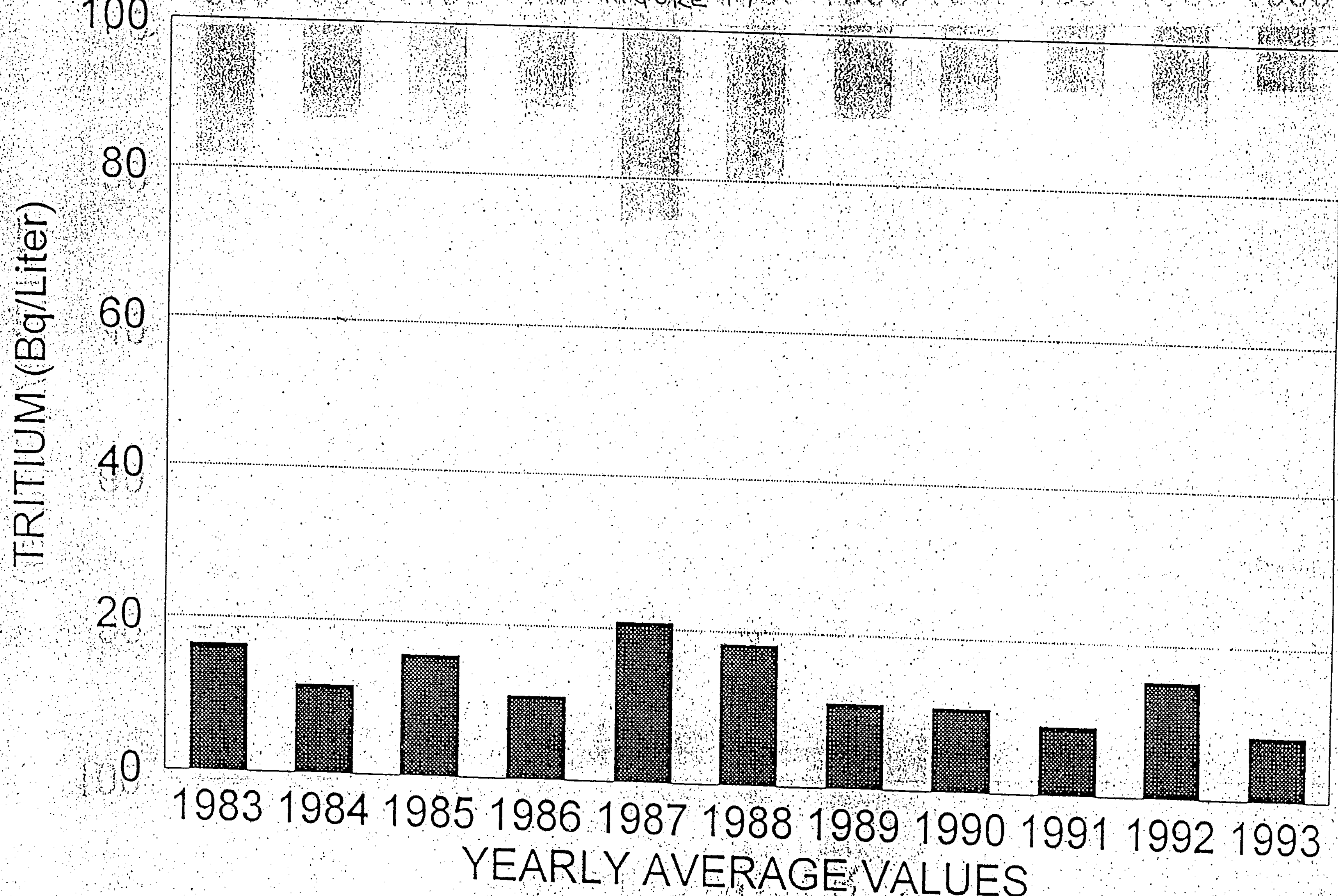

BOWMANVILLE WSP
DRINKING WATER
Figure 15
TRITIUM (Bq/Liter)
100
80
60
40
20
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
YEARLY AVERAGE VALUES


NEWCASTLE WSP
DRINKING WATER
FIGURE 16.
TRITIUM (Bq/Liter)
100
80
60
40
20
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
YEARLY AVERAGE VALUES

R.C. HARRIS WSP

DRINKING WATER

FIGURE 17



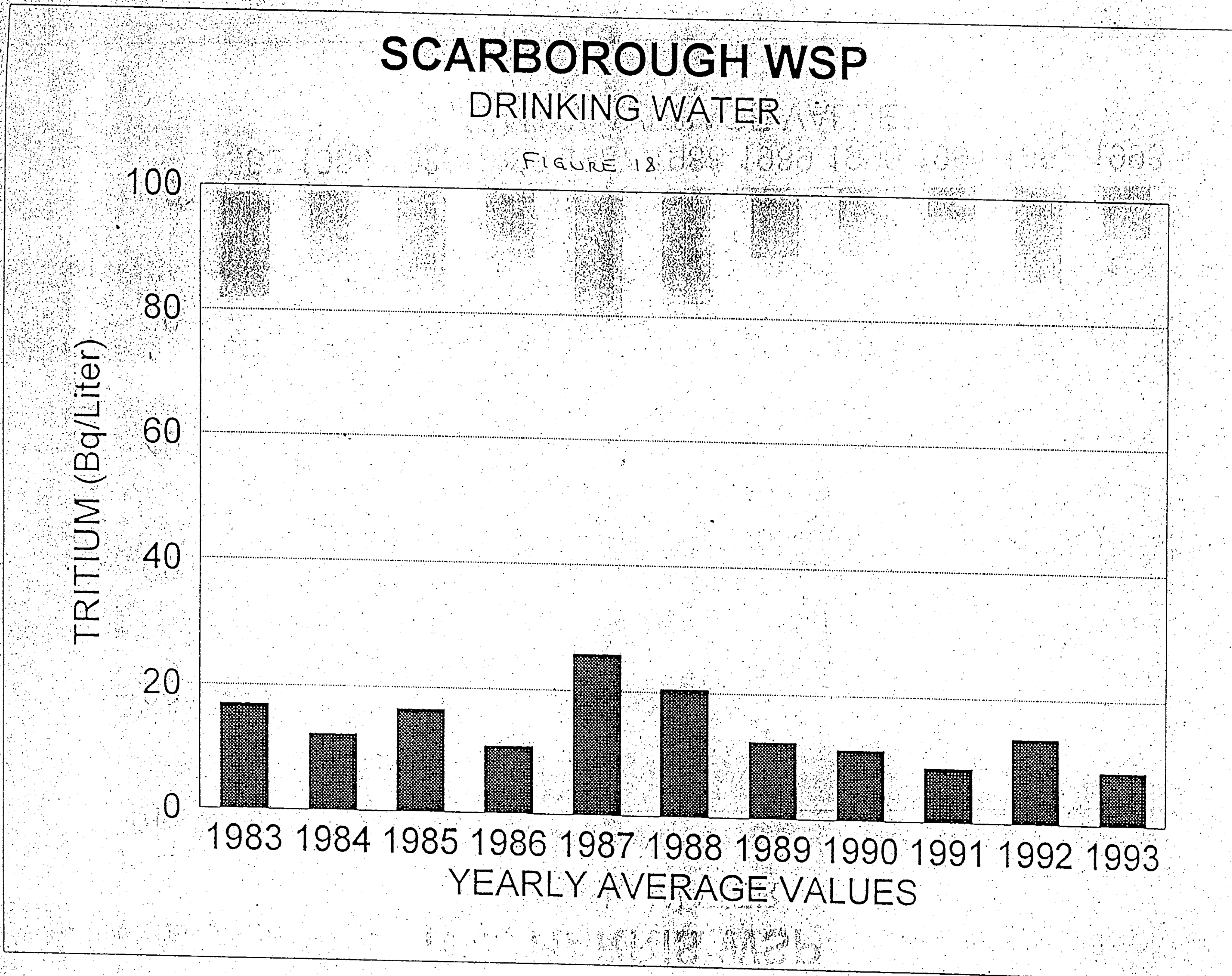
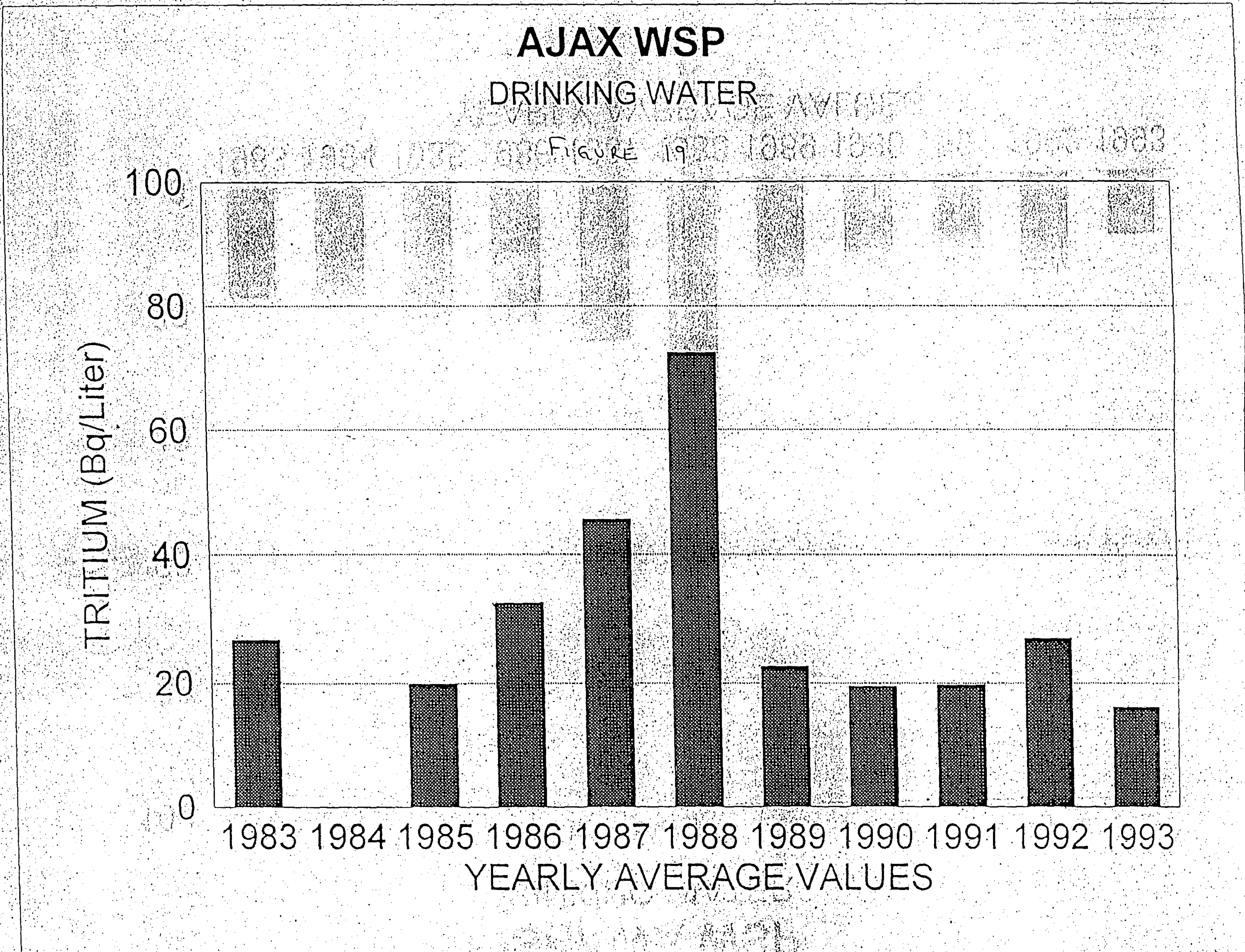
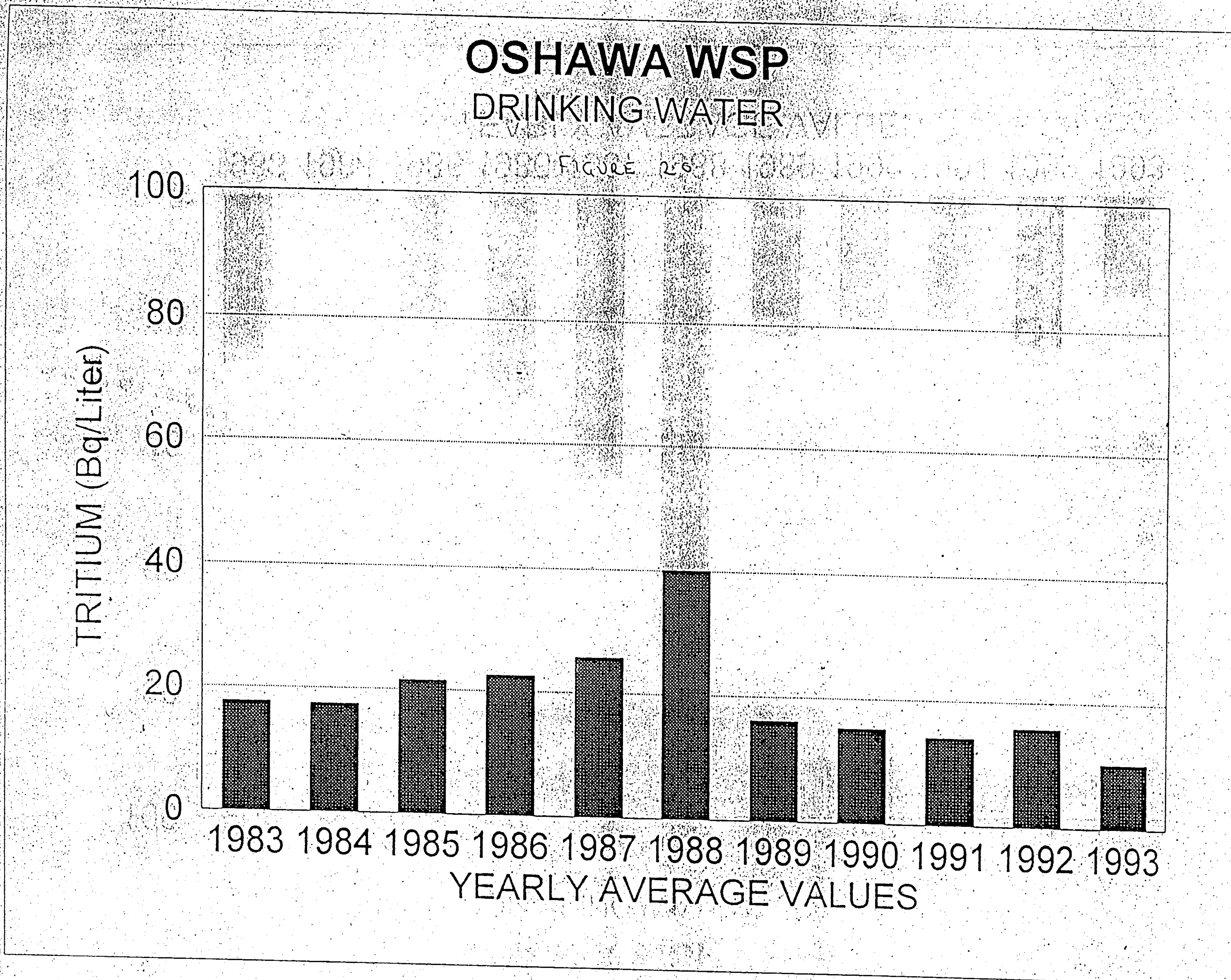
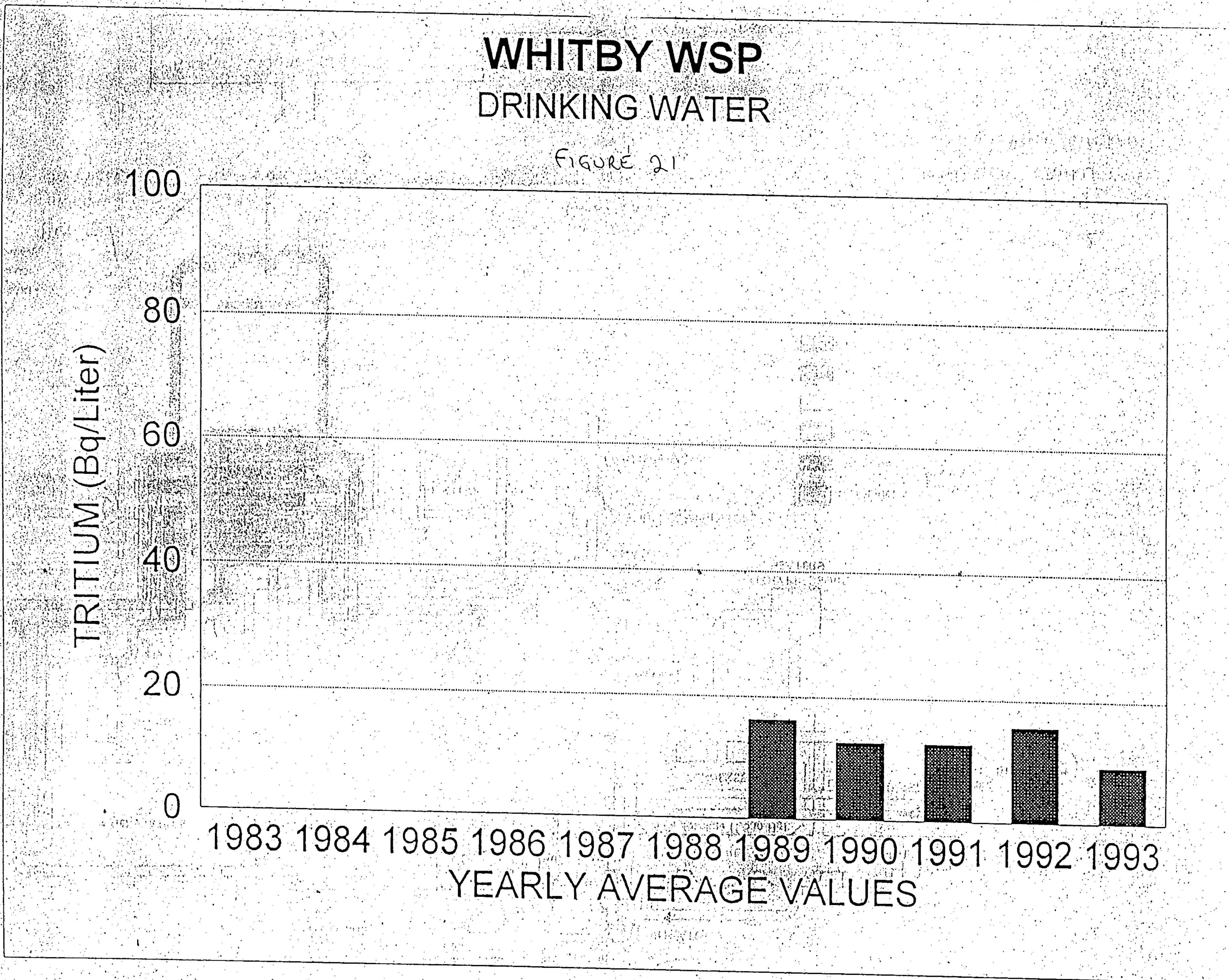

SCARBOROUGH WSP
DRINKING WATER
FIGURE 18
TRITIUM (Bq/Liter)
100
80
60
40
20
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
YEARLY AVERAGE VALUES

Figure 19


AJAX WSP
DRINKING WATER
TRITIUM (Bq/Liter)
100
80
60
40
20
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
YEARLY AVERAGE VALUES


OSHAWA WSP
DRINKING WATER
FIGURE 20
TRITIUM (Bq/Liter)
100
80
60
40
20
0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
YEARLY AVERAGE VALUES


WHITBY WSP
DRINKING WATER
FIGURE 21
100
80
60
40
20
0
TRITIUM (Bq/Liter)
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993
YEARLY AVERAGE VALUES

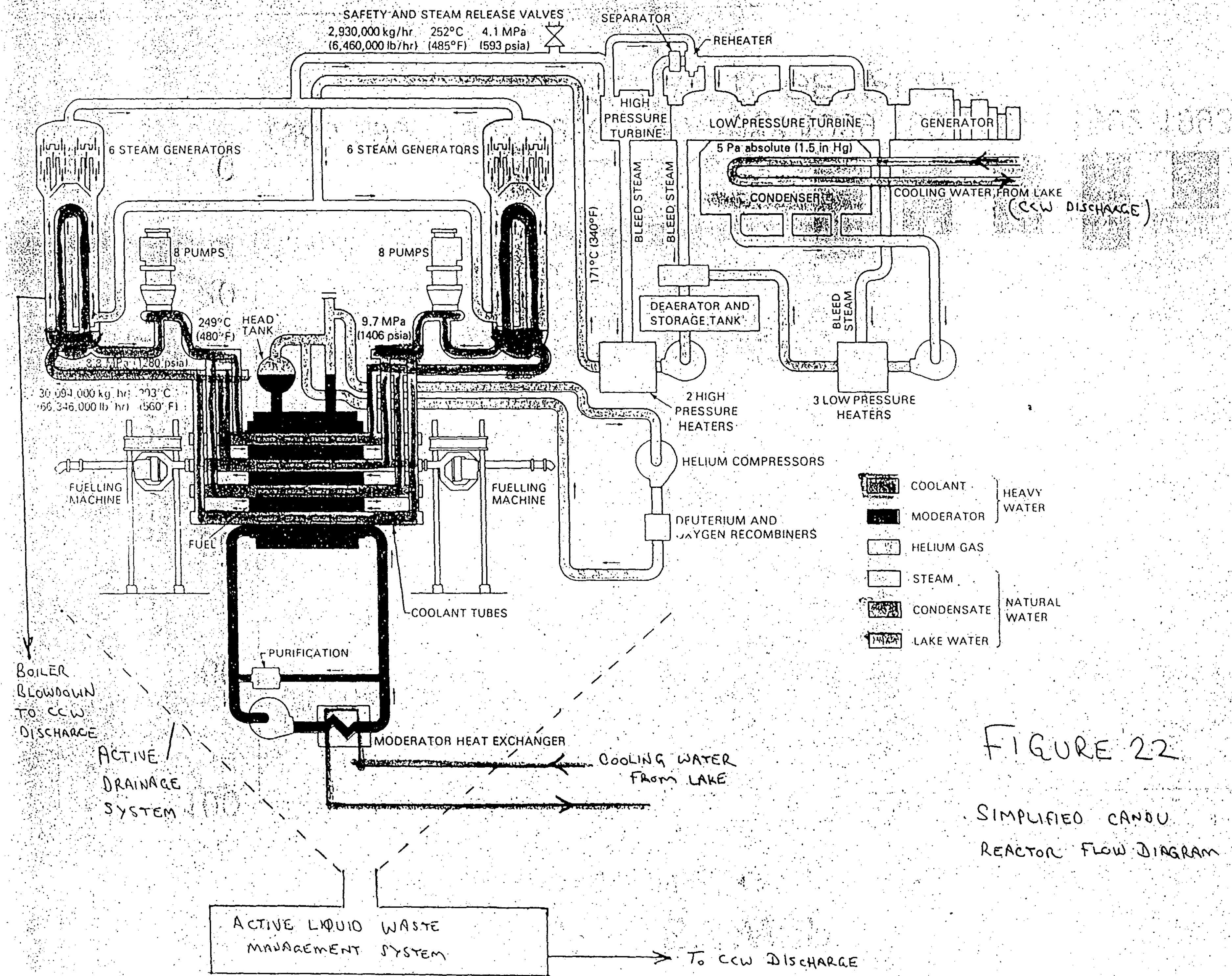


FIGURE 22

SIMPLIFIED CANDU REACTOR FLOW DIAGRAM

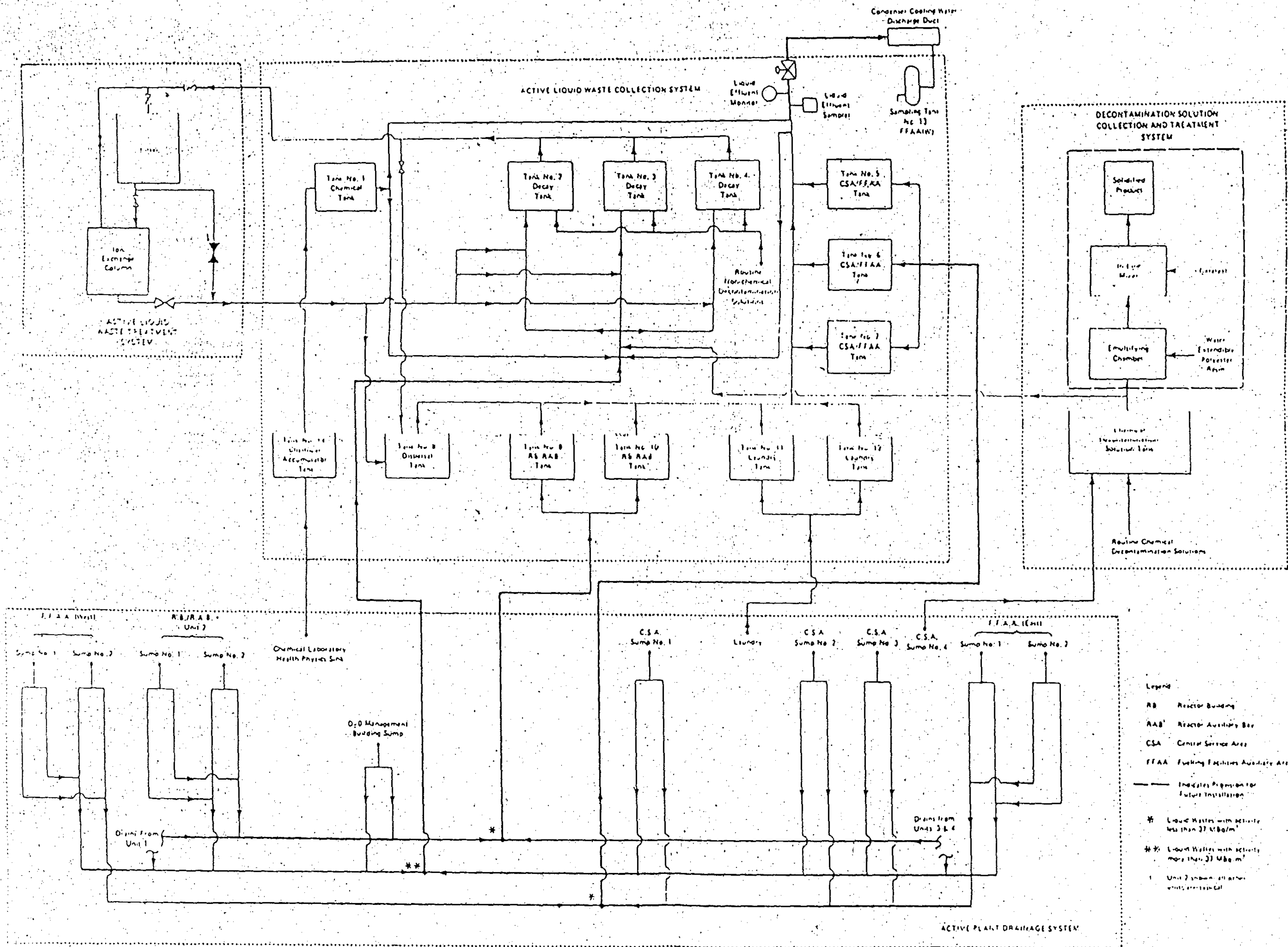


FIGURE 24 - DARLINGTON RADIOACTIVE LIQUID WASTE MANAGEMENT

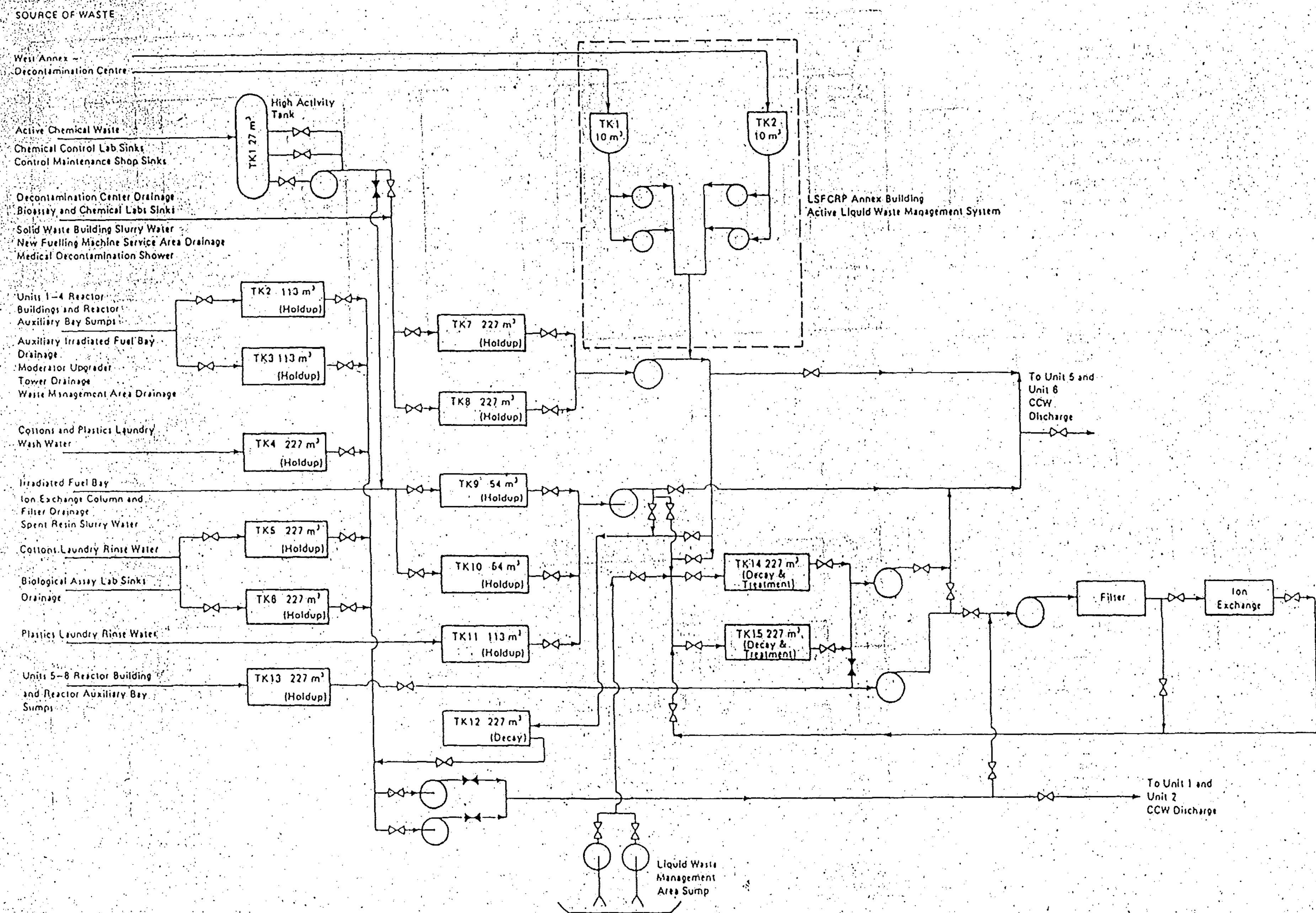


FIGURE 23 PICKERING – Active Liquid Waste Handling and Treatment – Flow Diagram

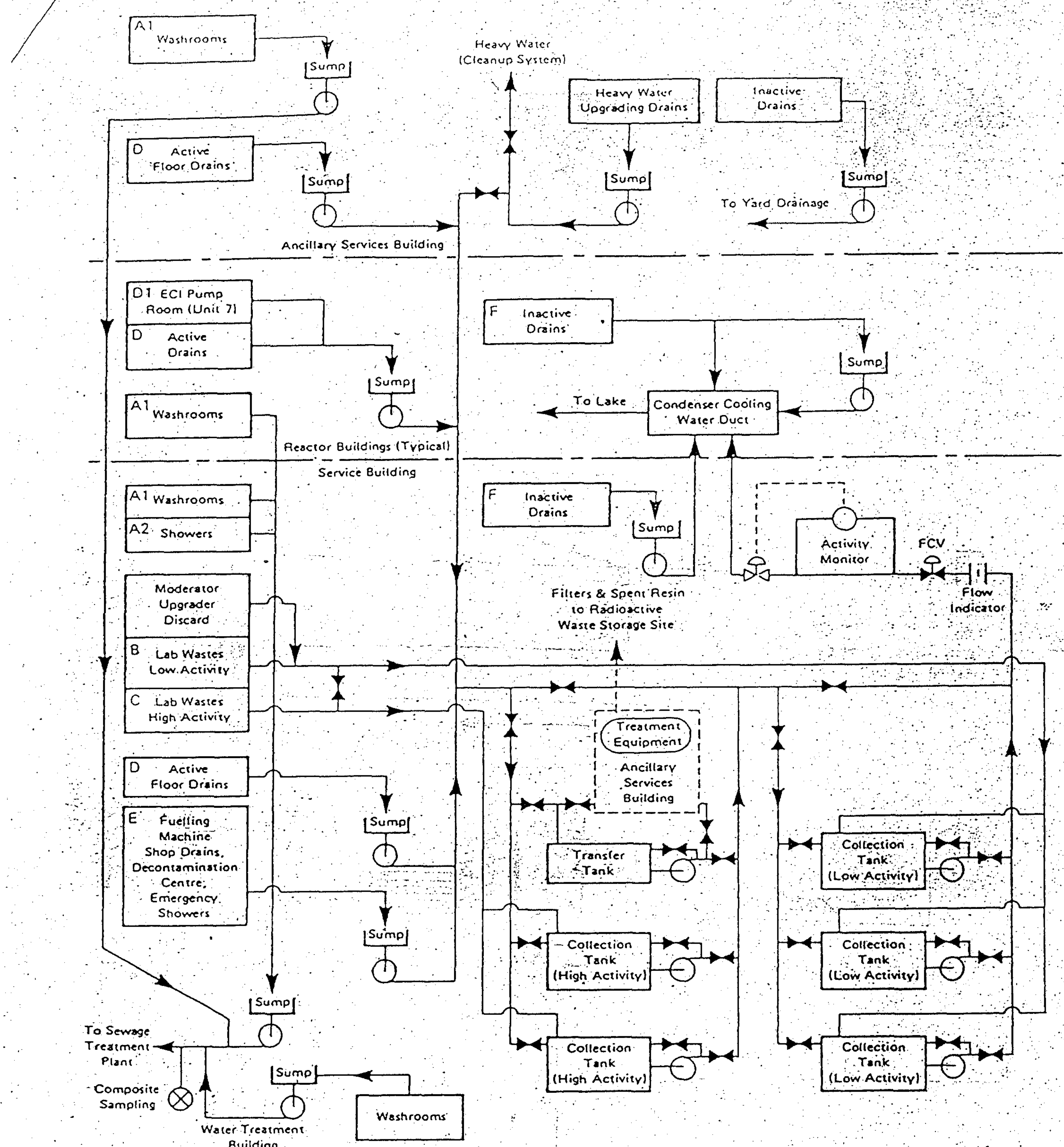


FIGURE 25 BRUCE

Active Liquid Waste Collection Handling and Treatment Systems Flow Digram

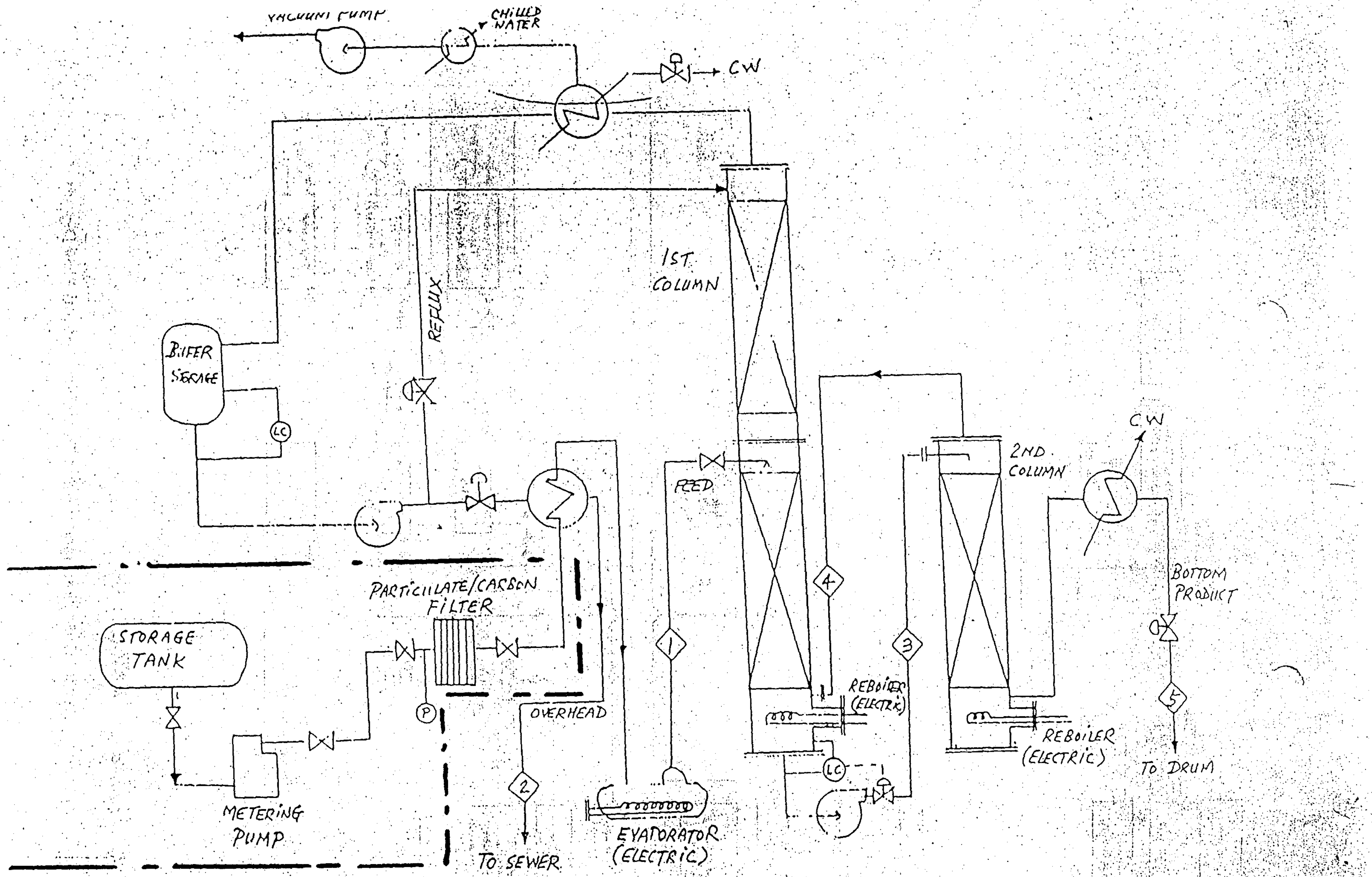


FIGURE 26— SCHEMATIC OF THE PROPOSED WASTE WATER DETRITIATION