SRB Technologies (Canada) Inc.

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2018 Annual Compliance and Performance Report

Reporting Period:	January 1 – December 31, 2018
Licence Number:	NSPFOL-13.00/2022
Licence Condition:	4.2

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SRB Technologies (Canada) Inc.

2018 Annual Compliance and Performance Report

Submission date: March 29, 2019

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Executive Summary

SRBT is pleased to provide this compliance and performance report to the Canadian Nuclear Safety Commission as part of our licensed activities.

Our facility continues to process tritium safely, responsibly and efficiently, and we are proud of the level of performance and degree of improvement that was achieved during 2018.

The ratio of the amount of tritium released to atmosphere versus the amount of tritium that we processed in 2018 rose slightly when compared to the previous year. For every 1,000 units of tritium that went into our products this year, 1.1 units of tritium was eventually released as gaseous effluent. This ratio (0.11%) met our annual target of 0.13%.

In 2018, SRBT processed 31,251,329 GBq of tritium into self-luminous light sources and safety devices; in comparison, in 2017, a total of 32,968,695 GBq of tritium was processed. The total amount of tritium released to the environment through the gaseous effluent pathway increased (33,180 GBq) compared with the previous year (24,822 GBq). The annualized gaseous tritium releases met our target for 2018; on the average, 638 GBq of tritium was released weekly, versus our target of 650 GBq per week.

The collective dose to workers at SRBT totalled 2.06 person·mSv, and no staff member exceeded 1 mSv for the year – a value that represents the dose limit to the public. As well, no action levels were exceeded with respect to radiation doses. This is a testament to the continued diligence of our workers in maintaining radiation exposures as low as reasonably achievable (ALARA).

The calculated public dose remains far less than 1% of the prescribed limit of 1 mSv, as derived from direct sampling and monitoring of the local environment. Groundwater tritium concentrations continue to respond favorably to modified and optimized processing practices.

In 2018, CNSC staff performed two inspections at the facility, resulting in one compliance item being identified in the area of Fitness for Service, as well as two security-related recommendations being tabled; all of these items have since been fully addressed to the satisfaction of CNSC staff.

Throughout the year, SRBT provided CNSC staff revisions of several key documents associated with our licensing basis, including but not limited to the Quality Manual, Fire Protection Program, Fire Safety Plan, Radiation Safety Program, Regulatory Reporting Program, Training Program and Waste Management Program.

As well, SRBT developed and implemented a new stand-alone program focused on dosimetry services. This new Dosimetry Service Program was accepted by CNSC staff as part of the issuance of a renewed Dosimetry Services Licence for a period of ten years.

The final deposit to the decommissioning escrow account was completed in April. With this transaction, the financial guarantee for our facility is now a fully-funded financial vehicle that does not rely on insurance, letters of credit or third party resources in order to ensure funding availability for future decommissioning of the facility.

In summary, 2018 represents a highly successful and safe year of operation for SRBT. Continual improvements in compliance and safety is an ongoing mission, and we will always strive to reduce our operational impact on the environment, and to optimize safety and the effective doses to our workers and the public.

Table of Contents

Acronyms and Abbreviations

ACR	Annual Compliance Report / Annual Compliance and Performance Report
AECL	Atomic Energy of Canada Limited
ALARA	As Low As Reasonably Achievable
Bq	Becquerel
BSI	British Standards Institute
CLC	Canada Labour Code
CLW	Clearance Level Waste
CN	Canadian National (railway)
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
CSM	Conceptual Site Model
CVC	Compliance Verification Criteria
dp	Differential Pressure
DS	Downspout
DSL	Dosimetry Service Licence
DU	Depleted Uranium
ECR	Engineering Change Request
EMP	Environmental Monitoring Program
EMS	Environmental Management System
ERA	Environmental Risk Assessment
ERM	Environmental Resources Management
ESDC	Employment And Social Development Canada
FASC	Facility Access Security Clearance
FPP	Fire Protection Program
GE	General Electric
GMP	Groundwater Monitoring Program
GTLS	Gaseous Tritium Light Source

Acronyms and Abbreviations

GWMP	Groundwater Monitoring Program
HT	Elemental Tritium
HTO	Tritium Oxide
HVAC	Heating, Ventilation, Air Conditioning
IAEA	International Atomic Energy Agency
IATA	International Air Transportation Agency
ISO	International Organization For Standardization
IT	Information Technology
LCH	Licence Conditions Handbook
LLW	Low-Level Waste
LSC	Liquid Scintillation Counters / Counting
LTI	Lost Time Incident
MDA	Minimum Detectable Activity
MW	Monitoring Well
MWC	Muskrat Watershed Council
NBCC	National Building Code of Canada
NCR	Non-Conformance Report
NDR	National Dose Registry
NFCC	National Fire Code Of Canada
NFPA	National Fire Protection Association
NIST	National Institute Of Standards And Technology
NSCA	Nuclear Safety And Control Act
NSPFOL	Nuclear Substance Processing Facility Operating Licence
OBT	Organically Bound Tritium
OFI	Opportunity For Improvement
OLC	Operating Limits And Conditions
OPG	Ontario Power Generation
PAS	Passive Air Sampler

Acronyms and Abbreviations

PDP	Preliminary Decommissioning Plan
PFD	Pembroke Fire Department
PIP	Public Information Program
PLC	Professional Loss Control
PTNSR	Packaging and Transport of Nuclear Substances Regulations
PUTT	Pyrophoric Uranium Tritium Trap
QA	Quality Assurance
QC	Quality Control
RDU	Remote Display Unit
REGDOC	Regulatory Document
RPD	Relative Percent Difference
RW	Residential Well
SAR	Safety Analysis Report
SAT	Systematic Approach To Training
SCA	Safety And Control Area
SRBT	SRB Technologies (Canada) Incorporated
SSC	Structure, System, And Component
SSR	Specific Safety Requirements
Sv	Sievert
TDG	Transportation Of Dangerous Goods
TSSA	Technical Standards And Safety Authority
UK	United Kingdom
UL	Underwriters' Laboratories
VLLW	Very Low-Level Waste
wc	Water Column
WHMIS	Workplace Hazardous Materials Information System
WMP	Waste Management Program
WSIB	Workplace Safety And Insurance Board

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List of Tables

List of Tables

List of Figures

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1. Introduction

1.1 General Introduction

For the period of January 1 – December 31, 2018, SRB Technologies (Canada) Inc. (SRBT) operated a tritium processing facility in Pembroke, Ontario, under Canadian Nuclear Safety Commission (CNSC) Nuclear Substance Processing Facility Operating Licence NSPFOL-13.00/2022[1].

The facility was operated in compliance with the regulatory requirements of the Nuclear Safety and Control Act (NSCA), our operating licences, and all other applicable federal, provincial and municipal regulations throughout the review period. No new licensed activities were implemented since the previous compliance monitoring report.

Compliance was ensured by the continued implementation of our Management System and associated programs and procedures, coupled with a high level of independent internal and external oversight through audit and inspection activities.

During this period, there were no exceedances of environmental or radiation protection action levels, nor licence / regulatory limits associated with our operating licence. One event relating to packaging and transport occurred during the year which was deemed to meet criteria for reporting to CNSC staff.

The SRBT operating licence includes conditions that require SRBT to prepare and submit an annual compliance report (ACR). This requirement is currently defined as part of the compliance verification criteria (CVC) in the Licence Conditions Handbook (LCH)[2] relating to condition 4.2 of NSPFOL-13.00/2022, which states:

> *The licensee shall submit an annual compliance report by March 31 of each year, covering the operation for the 12-month period from January 1 to December 31 of the previous year that includes at a minimum:*
>
> *a) Operational review including equipment and facility performance and changes, significant events/highlights that occurred during the year.*
> *b) Information on production including verification that limits specified in the licence was complied with.*
> *c) Modifications including changes in organization, administration and/or procedures that may affect licensed activities.*
> *d) Health physics information including operating staff radiation exposures including distributions, maxima and collective doses; review of action level or regulatory exceedance(s), if any, historical trending where appropriate.*
> *e) Environmental and radiological compliance including results from environmental and radiological monitoring, assessment of compliance with*

licence limits, historical trending where appropriate, and quality assurance/quality control results for the monitoring.

f) Facility effluents including gaseous and liquid effluent releases of nuclear substances from the facility, including unplanned releases of radioactive materials and any releases of hazardous substances.

g) Waste management including types, volumes and activities of solid wastes produced, and the handling and storage or disposal of those wastes.

h) Updates regarding activities pertaining to safety, fire protection, security, quality assurance, emergency preparedness, research and development, waste management, tritium mitigation and training (as applicable).

i) Compliance with other federal and/or provincial Regulations.

j) A summary of non-radiological health and safety activities, including information on minor incidents and lost time incidents.

k) A summary of stakeholder engagement activities, public opinion and information products, as committed to in the Public Information Program.

l) Forecast for coming year(s).

The purpose of this report is to provide the required information in order to meet the requirements of conditions 4.2 of Licence NSPFOL-13.00/2022, and the CVC in the associated LCH.

The information is reported in a format similar to that outlined in CNSC document *Annual Compliance Monitoring and Operational Performance Reporting Requirements for Class 1B Nuclear Facilities* (CNSC e-Doc 3471152)[3], and in consideration of regulatory feedback and comments regarding previous ACRs submitted over the past several years.

Where possible, information is presented in the most appropriate section / safety and control area, in such a way as to avoid duplication in other sections.

1.2 Facility Operation – Compliance Highlights and Significant Events

SRBT conducted its licenced activities in a safe and compliant manner throughout 2018.

1.2.1 Tritium Processing

In 2018, SRBT conducted 4,919 tritium processing operations (light source filling), with a total of 31,251,329 GBq of tritium being processed into gaseous tritium light sources (GTLS). Both of these values represent decreases over 2017 processing statistics (5,297 operations, 32,968,695 GBq).

Please refer to section 1.4, ‘Production or Utilization’ for additional details on tritium processing in 2018.

1.2.2 Production and Distribution of Self-luminous Safety Products

In 2018, 948 shipments of our self-luminous safety products were made to customers in 22 different countries, including Canada.

Please refer to section 4.8, ‘SCA – Packaging and Transport of Nuclear Substances’ for additional details on the production and shipment of our products in 2018.

1.2.3 Acceptance of Expired Products

In 2018, a total of 21,232 expired (or otherwise removed from service) self-luminous safety ‘EXIT’ type signs were accepted by SRBT from Canadian and American sources, representing a total activity of 3,530.29 TBq of tritium. In 2017, 18,977 signs were processed representing 3,599.10 TBq of tritium.

These signs were disassembled safely and the light sources removed, packaged and shipped to a licenced radioactive waste management service provider. A very small number of these signs were evaluated as having light sources that could be reused in other self-luminous devices.

As well, an additional 160.61 TBq of tritium was accepted from international origins (i.e. other than Canada and the United States) in the form of expired tritium illuminated devices, such as aircraft signs, dials, gauges and other smaller equipment. These were also processed for shipment to a licenced waste management facility.

Please refer to section 4.5, ‘SCA – Waste Management’ and section 4.8, ‘SCA – Packaging and Transport of Nuclear Substances’ for additional details on the acceptance of expired self-luminous safety signs in 2018.

1.2.4 External Oversight

During the year, there were a total of 11 major inspections or audits conducted by stakeholders and external parties on our operations.

CNSC staff conducted compliance inspections on two occasions, with one inspection being focused on Packaging and Transport, Conventional Health and Safety, and Fitness for Service, while the other inspection assessed our Security Program.

One Action Notice was issued to SRBT as a result of these inspections, as well as two recommendations. All compliance actions associated with these activities were addressed to the full satisfaction of CNSC staff.

BSI Management Systems, on behalf of the International Organization for Standardization (ISO), conducted a major audit of SRBT operations in September 2018. The audit verified our implementation of a quality management system aligned with the 2015 version of the ISO 9001 standard. The audit resulted in 3 opportunities for improvement being identified.

BSI concluded that SRBT continues to effectively manage our operations in a fashion that ensures the elements of the scope of our certification with ISO 9001 are effectively addressed, and certified SRBT to the 2015 version of ISO 9001.

A major customer of SRBT products also sponsored an independent audit of our operations in June, and a second customer-driven audit took place in October.

Underwriters' Laboratories (UL) completed four quarterly audits as planned. Ontario Power Generation did not perform an audit of our facility in 2018.

Additional details on the above noted external oversight of SRBT operations can be found in section 2.1, 'SCA – Management System'.

In addition, two focused facility inspections were conducted relating to fire protection. The Pembroke Fire Department inspected the facility in August, while Professional Loss Control (PLC) Fire Safety Solutions conducted a N393-13 compliant facility condition inspection in November, coupled with an audit of our Fire Protection Program. Details on these inspections can be found in section 4.4, 'SCA – Emergency Management and Fire Protection'.

1.2.5 Internal Oversight

Internally, seven internal compliance audits were conducted through the year, focused on all aspects of our operations and our organization. A total of 6 non-conformance reports (NCR) and 15 opportunities for improvement (OFI) were identified as a result of these activities, all of which have been addressed (or are in the process of being addressed) by the responsible managers.

Additional details on internal oversight of SRBT operations can be found in section 2.1, 'SCA – Management System'.

1.2.6 Reported Events

In line with our Regulatory Reporting Program, SRBT reported one event to CNSC staff in 2018, pertaining to the SCA of Packaging and Transport.

Details on the reported event can be found in section 2.3, 'SCA – Operating Performance', and in section 4.8, 'SCA – Packaging and Transport'.

1.2.7 Operational Challenges

SRBT experienced two significant operational challenges in 2018.

<u>Shipping Container Certification Issues</u>

Tritium gas is purchased in bulk quantities from Ontario Power Generation (OPG), who contract Canadian Nuclear Laboratories (CNL) to dispense and ship the material to our facility.

In order to ship this material, special certified Type 'B' shipping containers must be used, of which there are currently two designs authorized for use in Canada:

- General Electric (GE) Healthcare Ltd. 3605D (CNSC certificate number CDN/E204/-96)
- Atomic Energy of Canada Limited (AECL) Tritide Package (CNSC certificate number CDN/2060/B(U)-85)

The 3605D package has traditionally been used by CNL / OPG in shipping bulk tritium to their customers.

In 2017, issues arose with the international applicant (GE Healthcare) getting the 3605D package re-certified in the United Kingdom (UK), which ultimately had an effect on OPG being able to have the Canadian certificate renewed by the CNSC. The certificate (Rev. 5) had an expiry date of March 31, 2017 in Canada.

As a result, the Canadian certificate expiry date was extended by six months (from March to September 2017), to allow the UK certificate issue to be addressed by the applicant and the regulatory authority in the UK.

In August 2017, the UK regulatory authority issued a directive, instructing all 3605D package users to desist using the package until the design issues were resolved and the package was recertified.

As a result, OPG / CNL / SRBT immediately halted the use of the 3605D package, and began shipping and receiving bulk tritium using the AECL ‘2060’ tritide package.

The use of this package continued into 2018 without issue, while GE Healthcare and the UK regulatory authority worked towards dealing with the identified design issues with the 3605D container. In January, the UK regulatory body issued a renewed certificate to GE Healthcare for a period of five years.

OPG proceeded to apply for a renewed endorsement with CNSC staff once the UK certificate was issued. The 2060 package continued to be used as the endorsement / certification process continued into the spring. To this point, there had been no operational challenges, as tritium was still able to be delivered via the alternative 2060 tritide package.

On May 3, 2018, SRBT was informed by CNL that a scheduled shipment of tritium had been cancelled. The certificate holder for the 2060 tritide package had discovered discrepancies between the design basis documents of the container and the actual physical packages themselves.

The packages had been modified at some point in its history since the original certification; as such, CNL took the package out of service in order to resolve the design discrepancies, and reported the issue to the CNSC.

With the 2060 package being unavailable, and the 3605D certification by the CNSC still in process, OPG did not have a viable option to ship bulk tritium gas to our facility. Without a supply of tritium coming into the facility, significant operational challenges arose in filling customer orders by their expected delivery dates.

Production was throttled so as to focus on high-priority orders through early May; however, the tritium available to production was soon used up, and light source production was subsequently shut down on May 11 due to lack of tritium for processing operations.

Production remained shut down for more than two weeks. The problem of lack of tritium supply was finally resolved when, on May 23, CNSC issued a renewed package endorsement for the GE Healthcare 3605D container.

SRBT was registered as a user of this package on May 24, and a delivery of bulk tritium was received at the facility on May 25. Production activities resumed shortly thereafter. The rate of production was subsequently increased during the next several months in order to recover from the shut-down.

Although SRBT was significantly impacted by these container certification issues, at no time were there any safety issues in the packaging and transport of bulk tritium to the facility. We have used the operational experience gained as a result of these problems and begun to consider ways to reduce the potential impact of similar issues should they occur in the future.

Unexpected Loss of Import and Export Manager

In July, SRBT lost a key member of our team with the unexpected passing of our Import and Export Manager.

This individual was a member of the Health Physics team, and was responsible for several logistical aspects of our business and safety programs, including the management of import and export licences, nuclear substance inventory control, supervision and management of all shipping and receiving of nuclear substances, and a significant amount of resource support with respect to waste management.

As a result of this event, a temporary organizational shift had to take place in order to ensure continuity of our safety programs and our business. The Compliance Manager was seconded back to shipping and receiving as she had the most experience in this area (having held these responsibilities previously), while the Manager of Health Physics and Regulatory Affairs took on all responsibilities relating to waste management and import and export licensing.

Shortly after, training began for other employees to gain the knowledge and experience needed to take over these responsibilities. The Production Control Assistant began training to take over the responsibilities pertaining to nuclear substance inventory controls, shipping and receiving of nuclear substances, and the overall supervision of the shipping and receiving department, while the Health Physics Technician began training to take over the management of import and export licensing. The responsibilities in waste management were absorbed by the Manager of Health Physics and Regulatory Affairs as the responsible program manager.

At the end of 2018, training of the Production Control Assistant and the Health Physics Technician was nearing completion, with the formal transition of responsibilities expected to be completed in the first quarter of 2019.

Although the loss of the Import and Export Manager greatly affected and saddened our team, and presented an operational challenge, safety has been assured throughout the transitional period by careful management of resources and focused training and oversight in the impacted areas.

1.2.8 Summary of Significant Modifications

No significant modifications were implemented in the facility which pertain to our licensed activities in 2018, and there were no changes to the production capacity of the facility.

Any modifications to structures, systems and components associated with our licensed activities were relatively minor, did not impact upon our licensing basis, and were conducted in accordance with our change control processes.

Please refer to section 3.2, ‘SCA – Physical Design’, for more information regarding notable facility modifications carried out in 2018.

1.2.9 Summary of Organizational Structure and Key Personnel

The organizational structure of SRBT remained the same through 2018 as in 2017.

At the conclusion of 2018, SRBT employs 42 employees and managers.

Please refer to section 2.1, ‘SCA – Management System’ for details regarding SRBT’s organizational structure in 2018.

1.3 Summary of Compliance with Licence and OLCs

Throughout 2018, SRBT complied with the conditions of our operating licence, and possessed, transferred, used, processed, managed and stored all nuclear substances related to the operation of the facility in compliance with regulatory requirements.

Specifically:

- All required programs have been implemented and maintained,
- The CNSC was notified as required of changes to the programs, processes and documents referenced in the management system / licensing basis,
- All required records have been established and maintained pursuant to the operating licence, the Nuclear Safety and Control Act and its regulations,
- All pertinent notifications were made, and written reports filed, within prescribed periods,
- An accepted decommissioning strategy continues to be maintained for future use,
- An accepted financial guarantee was maintained for decommissioning, and payments made in accordance with the relevant schedules,
- Cost recovery fees were paid on time and in full, and
- Limits on releases of tritium to the atmosphere and sewer, and radiation dose limits to the public and SRBT nuclear energy workers were not exceeded.

SRBT also remained in compliance with requirements of all other federal and provincial regulations as pertaining to the operation of the facility, including the Canada Labour Code and associated regulations, as well as provincial regulations with respect to the management of hazardous materials and waste.

The following summary report is provided respecting SRBT compliance with the Operating Limits and Conditions (OLC) established within our Safety Analysis Report (SAR) throughout the course of 2018.

Each applicable OLC is repeated below, with a statement of compliance.

1.3.1 Tritium Possession Limit

SRBT is authorized by licence to possess up to 6,000 TBq of tritium in any form.

SRBT possessed less than 6,000 TBq of tritium at all times during 2018.

Please refer to section 2.3, ‘SCA – Operating Performance’ for more details.

1.3.2 Tritium Processing – Permitted Hours of Operation

Tritium processing operations consist of filling and sealing of gaseous tritium light sources (GTLS) on processing rigs, laser cutting of GTLS, or bulk splitting operations. Tritium processing operations are restricted to 0700h – 1900h, seven days a week, unless specifically approved by senior management.

All tritium processing operations were conducted between the hours of 0700h and 1900h during 2018. No processing occurred outside of this time period.

1.3.3 Tritium Processing – Precipitation

Tritium processing shall not occur during measurable periods of precipitation, as detected by the precipitation detection system or equivalent.

Tritium processing operations were only conducted during periods where measureable precipitation was not occurring during 2018.

Processing operations were ceased and equipment placed into a safe state when precipitation events occurred during operating hours.

1.3.4 Tritium Releases to Atmosphere – Tritium Oxide

SRBT shall not release in excess of 6.72E+13 Bq of tritium oxide to atmosphere in any year.

The total amount of tritium oxide (HTO) released to atmosphere in 2018 was equal to 1.07E+13 Bq (10,741 GBq), representing 16.0% of this licenced limit.

Please refer to section 4.3 ‘SCA – Environmental Protection’ for more details.

1.3.5 Tritium Releases to Atmosphere – Tritium Oxide + Elemental

SRBT shall not release in excess of 4.48E+14 Bq of total tritium as tritium oxide and tritium gas to atmosphere in any year.

The total amount of combined HTO and elemental tritium (HT) released to atmosphere in 2018 was equal to 3.32E+13 Bq (33,180 GBq), representing 7.4% of this licenced limit.

Please refer to section 4.3 ‘SCA – Environmental Protection’ for more details.

1.3.6 Minimum Differential Pressure Measurements for Tritium Processing

Tritium processing operations shall not occur unless the following differential pressures are achieved, as measured by the gauges on each of the active ventilation system stacks:

- Rig Stack: 0.27 inches of water column (wc)
- Bulk Stack: 0.38 inches of water column

These measurements correspond to an average effective stack height of 27.8 metres, assuming a wind speed of 2.2 m/s.

At no time did tritium processing occur during 2018 when the noted differential pressures (dp) were not being achieved, as measured daily prior to operations commencing.

1.3.7 Tritium Releases to Sewer – Water-soluble Tritium

SRBT shall not release in excess of 2.00E+11 Bq of water soluble tritium to the municipal sewer system in any year.

The total amount of water soluble tritium released to the municipal sewer in 2018 was equal to 1.01E+10 Bq, representing 5.0% of this licenced limit.

Please refer to section 4.3 ‘SCA – Environmental Protection’ for more details.

1.3.8 PUTT Filling Cycles

Any pyrophoric uranium tritium trap (PUTT) base is limited to 30 complete bulk splitter filling cycles, after which it is no longer permitted to be used for further tritium processing.

All tritium processing in 2018 was conducted using PUTTs that had been cycled 30 times or less on the bulk splitter.

1.3.9 PUTT / Bulk Container Tritium Loading Limit

> PUTTs are limited to less than 111,000 GBq of tritium loading at any time.
>
> Bulk containers are limited as follows:
>
> - SRBT shall request no more than 925,000 GBq per bulk container when submitting a purchase order to an approved supplier of tritium gas.
> - No bulk container shall exceed 1,000,000 GBq of tritium loading at any time.

In 2018, no PUTT was loaded with more than 111,000 GBq of tritium.

No bulk container was used in the facility in excess of the 1,000,000 GBq loading limit.

1.3.10 Bulk Container Heating Limit

> Bulk tritium containers are limited to a heating temperature of approximately 550 °C, as measured by the thermocouple placed between the heating band and the container surface.
>
> Brief and small exceedances of this value are tolerable so long as they are not sustained, and the temperature is returned below this value as soon as possible.

Bulk tritium container heating operations were conducted in compliance with this limit throughout 2018.

1.3.11 On-site Depleted Uranium Inventory

> The on-site physical inventory of depleted uranium (virgin, in use and decommissioned bases) is limited to 10 kg.

The on-site inventory of depleted uranium (DU) did not exceed 10 kg in 2018.

Please refer to section 2.3, ‘SCA – Operating Performance’, and section 4.5 ‘SCA – Waste Management’ for more details on inventory controls of DU in 2018.

1.3.12 Exceedances of Facility Action Levels

There were no exceedances of radiation protection or environmental protection action levels in 2018.

Facility action levels are next scheduled for review in 2019.

1.4 Production or Utilization

1.4.1 Tritium Processing

In 2018, at total of 31,251,329 GBq of tritium was processed. This represents an decrease of about 5% from the 2017 value of 32,968,695 GBq.

The following table is presented to illustrate the five-year history of tritium processing at SRBT.

TABLE 1: TRITIUM PROCESSED – FIVE-YEAR HISTORY

Calendar Year	2014	2015	2016	2017	2018
Tritium Processed (GBq)	28,714,119	27,989,832	28,122,678	32,968,695	31,251,329

1.4.2 Tritium Possession

SRBT is restricted by licence to possess no more than 6,000 TBq of tritium in any form at the facility at any time.

Throughout 2018 this possession limit was not exceeded. The maximum tritium activity possessed at any time during 2018 was 4,531 TBq, in December. The monthly average inventory of tritium in the facility was 3,683 TBq.

At all times, unsealed source material was stored on tritium traps or in the handling volumes of tritium processing equipment.

The monthly data of tritium activity on site during calendar year 2018 can be found in **Appendix A** of this report.

1.5 Changes in Management System Documentation

In 2018, SRBT revised several key program-level documents associated with our licensing basis, following the change control provisions of our Licence Conditions Handbook.

These include:

- Quality Manual,
- Radiation Safety Program,
- Fire Protection Program,
- Fire Safety Plan,
- Regulatory Reporting Program,
- Security Program,
- Training Program Manual, and
- Waste Management Program,

As well, SRBT developed and implemented a new stand-alone Dosimetry Service Program in support of the renewal of our Dosimetry Service Licence.

In line with our mission and policy of continual improvement, process and procedural revisions continued to be a managerial focus throughout the year. In total, 60 Engineering Change Requests (ECRs) were generated to control the revision and review of programs, procedures or forms in 2018.

Specific details on the changes in documentation can be found in section 2.1, ‘SCA – Management System’.

2. Management SCAs

2.1 SCA – Management System

Throughout 2018, the SRBT management system was effectively implemented, and ensured that our operations continued to meet the requirements detailed in our LCH, including key elements such as organization and responsibilities, capability of personnel, use of experience, work planning and control, process and change control, independent verification, non-conformance and corrective action.

A total of 69 non-conformances (NCR) and 54 opportunities for improvement (OFI) were raised in different areas of the company operations.

As of the end of 2018, 48 out of the 69 NCRs raised in 2018 had been addressed, reviewed for effectiveness and closed, with all having been evaluated as being effective in correcting the issue identified.

The remaining 21 NCRs are still in progress due to the relative longer timeframes for the actions that are to be taken to resolve the issues identified.

For opportunities for improvement (OFIs), 32 out of the 54 raised in 2018 have been addressed, reviewed for effectiveness and closed, with all having been evaluated as being effective in achieving the improvement identified.

The remaining 22 OFIs were assigned target completion due dates that have not yet been reached, and will be reviewed as per normal processes once the responsible individual addresses the OFI.

SRBT affirms that corrective actions and opportunities for improvement have been effective at resolving problems and promoting the concept of continual improvement within our management system in 2018.

Organizational Management Reviews were conducted in early 2018 by all program owners and responsible managers, including benchmarking and self-assessment activities. Reports were submitted to the Compliance Manager in preparation for the annual Management Review.

This review was conducted by way of a meeting of the Executive Committee, held on March 8, 2018, where the results of the benchmarking and self-assessment activities performed for the previous calendar year were reported and discussed, and areas where improvements could be made in the various company safety programs were highlighted.

The management system was found to be effective at meeting the current requirements of the NSCA, associated regulations and the conditions of the operating licence, as well as ISO 9001:2015, and customer requirements.

The 2018 Organizational Management Reviews are scheduled to take place in early 2019, followed by a meeting of the Executive Committee to discuss the outputs of the reviews, and identify any opportunities for improvements, actions required to mitigate risks, and compliance or performance issues.

2.1.1 Staffing and Organization

At the beginning of 2018, SRBT total staff complement stood at 44 employees,.

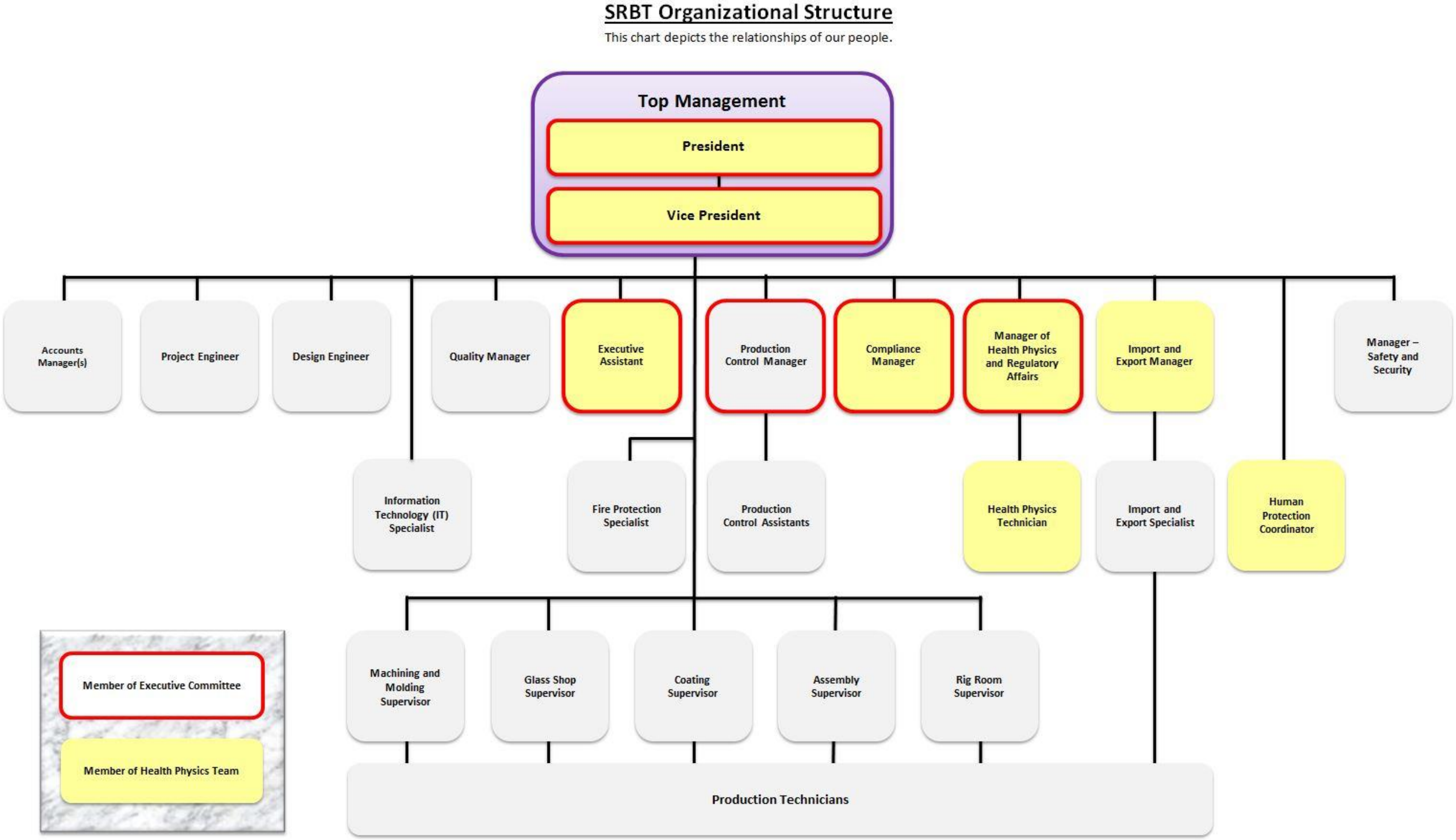
Six of these employees are no longer employed by the company, while four new employees were hired during the year. As of the end of 2018, the total staff complement stands at 42 employees.

There were no significant organizational structure changes implemented in 2018. An individual is being trained to fulfill the packing and shipping responsibilities of the Import and Export Manager, after the individual who held this position passed away unexpectedly in July. Another individual in our organization is being trained to fulfill the import and export licensing responsibilities previously held by the Import and Export Manager.

Once fully trained in these responsibilities, these individuals will hold new organizational titles, and the requisite change in the organizational structure will be executed.

The following organizational chart represents the structure of the company, as of the end of 2018, that ensures SRBT meets the Nuclear Safety and Control Act, regulations and conditions of our operating licence.

FIGURE 1: ORGANIZATIONAL CHART



As of the end of 2018, a total of 42 employees work at the company, including 19 administrative employees and 23 production employees.

Administrative employees include two members of Top Management:

- President has the overall responsibility for the facility and ensures that all licensing requirements are met.
- Vice President assumes the full duties of the President in his absence or otherwise assists the President's in his duties.

Eleven individuals at the Organizational Management level:

- Quality Manager is mainly responsible for ensuring the quality of products, the satisfaction of customers, and adherence to the requirements of the Underwriters Laboratories (UL). They also provide input ensuring that our management system meets the requirements of the ISO 9001 standard.
- Import and Export Manager (will change to Logistics Manager in early 2019) is mainly responsible for the transport, receipt and inventory of radioactive materials, and the conduct of import and export activities.
- Executive Assistant is mainly responsible for providing administrative support to the President, and for ensuring meeting minutes are recorded.
- Production Control Manager is mainly responsible for all company purchasing and production planning activities.
- Project Engineer is mainly responsible for all company research and development activities, change control process, and the company maintenance program.
- Design Engineer is mainly responsible for certain key manufacturing processes, quality assurance of goods received, and developing specifications for components and material purchases.
- Account Managers (2) are mainly responsible for all company accounting activities.
- Manager – Safety and Security is mainly responsible for ensuring staff health and safety and ensuring compliance with the Occupational Health and Safety Regulations, and support for the Security Program.
- Compliance Manager is mainly responsible for performing independent internal audits and further ensuring facility compliance with external and internal requirements.
- Manager of Health Physics and Regulatory Affairs is mainly responsible for oversight of all company Health Physics activities as well as communicating with CNSC staff to ensure deadlines are met.

Six employees provide program oversight and/or directly assist individuals at the Management level,

- IT Specialist (2) manage and maintain the facility computer network and provide a wide range of technical and engineering support.
- Human Protection Coordinator provides advice to workers and contractors to ensure they are aware of the hazards associated with tritium and the methods of protecting themselves from these hazards. This individual is also responsible for implementation and verification of the outputs of several processes relating to the Radiation Safety Program.
- Fire Protection Specialist ensures that facility fire safety procedures are implemented.
- Health Physics Technician performs duties relating to radiation and environmental protection, and is responsible to fulfill duties pertaining to import and export licensing.
- A Health Physics student has been retained since May, responsible for executing several processes relating to environmental and radiation protection.

The twenty-three production employees include five Production Supervisors:

- Glass Shop Supervisor is responsible for all the activities within the Glass Shop Department.
- Coating Supervisor is responsible for all the activities within the Coating Department.
- Rig Room Supervisor is responsible for all the activities within the Rig Room Department.
- Assembly Supervisor is responsible for all the activities within the Assembly Department.
- Machining and Molding Supervisor is responsible for all the activities within the Machining and Molding Department.

These supervisors oversee the work of eighteen Production Technicians,

- Production Technicians who are responsible for performing production activities to company procedures.

2.1.2 Committees

In 2018, committees have continued to be instrumental in the development and refinement of company programs and procedures, identifying new safety initiatives and ensuring continuing effective communication at all organizational levels.

Committees use meeting results as an opportunity for improvement and make recommendations accordingly. In 2018, a total of 77 committee meetings took place at the company compared to 74 in 2017.

TABLE 2: COMMITTEE MEETINGS

COMMITTEE	NUMBER OF MEETINGS
PRODUCTION COMMITTEE	31
WORKPLACE HEALTH AND SAFETY COMMITTEE	9
HEALTH PHYSICS COMMITTEE	8
MAINTENANCE COMMITTEE	6
PUBLIC INFORMATION COMMITTEE	4
FIRE PROTECTION COMMITTEE	4
OTHER COMMITTEE / STAFF MEETINGS	3
MITIGATION COMMITTEE	3
TRAINING COMMITTEE	3
SAFETY CULTURE COMMITTEE	3
EXECUTIVE COMMITTEE	2
WASTE MANAGEMENT COMMITTEE	1
TOTAL	**77**

Committee meetings continue to be a key force to improve all aspects of our operations, and safety in general.

2.1.3 Review of Quality Assurance and Management System Effectiveness

The SRBT management system is subject to both focused periodic review, as well as continuous review and improvement.

Based upon the following factors, and the information presented in this report, it is concluded that the SRBT management system has been effective throughout the year:

- Zero lost-time injuries or incidents occurring in 2018,
- All workplace injuries were relatively minor in nature,
- Highest worker dose for 2018 is again less than 1% of the regulatory limit,
- Maximum calculated public dose remains less than 1% of the regulatory limit for persons who are not nuclear energy workers,
- Continued low ratio of tritium released vs. processed,
- Gaseous tritium oxide releases were less than 20% of authorized limits, while combined oxide and elemental tritium releases were less than 10% of authorized limits,
- Tritium releases via liquid effluent were less than 10% of authorized limits,
- All conditions of our facility operating licence met throughout the year,
- No open CNSC compliance actions as of the end of 2018,
- Continued improvement of several key programs and processes, and
- Continuous registered certification to the latest revision of the ISO 9001 standard.

2.1.4 Audit Summary – Internal

The goal of SRBT's internal auditing process is to ensure that all licensed activities and company safety programs and procedures are being adhered to.

Internal audits are often specifically focused on the safety and control areas established by the CNSC.

The Compliance Manager implemented an audit schedule for 2018 that touched on several aspects of our operations.

A total of 7 internal audits were completed, focused in the following areas of our operations:

- Management System
- Personnel Training
- Security
- Waste Management
- Safety Analysis
- Production Departments
- Shipping and Inventory Control

Internal audits resulted in 6 non-conformances (NCR) and 15 opportunities for improvement (OFI) being identified in 2018. Actions have been established and tracked in each case in order to drive compliance and continuous improvement.

2.1.5 Audit Summary – External

During the year, there were a total of 11 major inspections or audits conducted by stakeholders and external parties on our operations.

2.1.5.1 CNSC Inspections (2)

CNSC staff conducted compliance inspections on two occasions, focused on specific safety and control areas relating to our operations.

In February, CNSC staff conducted a compliance inspection (SRBT-2018-01) focused on the Security safety and control area.

As a result of the inspection, two Recommendations were issued[4], which were satisfactorily addressed by SRBT[5].

In March, CNSC staff conducted a compliance inspection (SRBT-2018-2) focused on three safety and control areas: Packaging and Transport, Conventional Health and Safety, and Fitness for Service.

As a result of the inspection, one Action was issued[6], which was addressed by SRBT within three months of receiving the inspection report[7]. CNSC staff closed the inspection file on August 27, 2018[8].

At the conclusion of 2018, there are no outstanding compliance actions associated with the SRBT operating licence.

2.1.5.2 ISO Certification Audits (1)

On behalf of the International Organization for Standardization (ISO), BSI Management Systems conducted an audit in September for calendar year 2018, as part of the maintenance of SRBT's ISO 9001 certification.

The audit resulted in three opportunities for improvement being identified that have since been addressed, or are in the process of being addressed at the conclusion of 2018.

2.1.5.3 Customer-Led Audits (2)

An external audit of a wide range of our manufacturing operations was conducted in June by Environmental Resources Management (ERM) Group, an independent auditing agency, on behalf of a major customer.

As well, a major customer (Isolite) executed a product-focused quality audit of our facility in October.

2.1.5.4 Underwriters Laboratories (4)

Underwriters Laboratories (UL) provides safety-related certification, validation, testing, inspection, auditing, advising and training services to a wide range of clients, including manufacturers.

UL performs quarterly visits of our facility. These visits are unannounced and are to ensure compliance that the products we produce which are listed with UL are manufactured using the materials, procedures and testing parameters required under the specific UL listing.

In 2018, UL performed inspections on March 20, May 25, October 10 and December 5, with no variation notices being raised through the year.

2.1.5.5 Fire Protection Inspections (2)

Two focused facility inspections were conducted relating to fire protection.

The Pembroke Fire Department inspected the facility in August, with no violations being identified.

Professional Loss Control (PLC) Fire Safety Solutions conducted a N393-13 compliant site condition inspection in November, coupled with an audit of our Fire Protection Program. One finding pertaining to the program was identified, as well as one opportunity for improvement.

The program finding was remedied by implementation of a new fire protection procedure, while the opportunity for improvement arising from the site condition inspection was rectified immediately.

Details on these inspections can be found in section 4.4, ‘SCA – Emergency Management and Fire Protection’.

2.1.5.6 SRBT Audits of Suppliers, Manufacturers or Service Providers

SRBT did not perform an audit of any suppliers, manufacturers or service providers in 2018.

2.1.6 Benchmarking and Self-assessments

In 2018, individuals responsible for specific programs and procedures at SRBT regularly looked at process problems, corrective actions as well as trending and used this information to benchmark elsewhere in or out of the organization in order to improve the effectiveness of these programs and procedures and to help define where improvements could be made.

Benchmarking against other similar CNSC licensees was encouraged. Documents describing the performance of similar CNSC licensees were reviewed:

- Commission Member Documents
- Proceedings, Including Reasons for Decision
- Documents from other licensees, including annual compliance reports

Self-assessments are also performed by Organizational Managers to identify, correct and prevent problems that hinder the achievement of the company's vision, mission, goals, values and policy and to assess the adequacy and effectiveness of the Quality Management System.

Self-assessments were performed by review of:

- Analysis and trending of performance data against historical data
- Input from stakeholders (public, contractors, regulators, etc.)
- Workspace inspections or observations
- Routine communications with staff to determine whether expectations are understood
- Training and coaching results
- Corrective and preventive actions raised throughout the organization
- Internal audit results

Both Benchmarking and Self-assessment reports formed key inputs into the annual Management Review meeting conducted on March 8, 2018, leading to several actions to address issues and risks, as well as opportunities for improvement.

2.1.7 Programs and Procedures

2.1.7.1 Programs and Major Licensing Documents

In 2018, several key management system programs and plans were revised in line with SRBT's mission of continuous improvement.

On January 8, 2018, SRBT received CNSC staff comments[9] on Revision L of the **Radiation Safety Program**, which had been submitted for review on October 31, 2017[10]. Based upon this feedback, SRBT further revised the program document and submitted it for approval on January 19, 2018[11]. CNSC staff accepted Revision M of the program on February 1, 2018[12].

On January 12, 2018, SRBT received confirmation that Revision 4 of the **Safety Analysis Report** was accepted as complete with no further comment from CNSC staff[13]. It had been submitted for review on November 10, 2017[14].

On January 29, 2018, SRBT submitted Revision K of the **Quality Manual** to CNSC staff for review and acceptance[15]. The manual was revised in order to address a minor issue that had been identified during an external audit by SRBT's ISO 9001 certifying organization. The manual was accepted by CNSC staff on January 31, 2018[16].

SRBT submitted two revised procedures to CNSC staff on March 27, 2018[17]. Both **RSO-009, *Tritium Inventory Management*** and **RSO-029, *Nuclear Substances Inventory Management*** are listed in our LCH as documents which require notification to be furnished to CNSC staff upon implementation after any changes. CNSC accepted these procedures on May 16, 2018[18].

On April 12, 2018, in response to a request from the Director General of the CNSC Directorate of Nuclear Cycle and Facilities Regulation[19], SRBT submitted a gap analysis document pertaining to CNSC Regulatory Document (REGDOC) 3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills.* The submission[20] included Revision B of SRBT's **Regulatory Reporting Program**, which addressed all identified gaps and issues between the REGDOC and our program.

The Security Program was revised and submitted[5] to CNSC staff in order to incorporate recommendations made during the February inspection.

Revision G of the **Waste Management Program** was submitted to CNSC staff for review and acceptance on April 12, 2018[21]. This revision was implemented in order to reference the management of non-radioactive waste materials generated by our 3D printing processes. Comments were received on May 15, 2018[22], which were addressed three days later[23]. The program was accepted by CNSC staff on June 12, 2018[24].

On May 25, 2018, SRBT submitted Revision C of the **Training Program Manual** to CNSC staff for review and acceptance[25]. Several improvements were made to the processes in the manual based upon operating experience and feedback over the first three years of implementation, as well as based upon internal audits and revised regulatory guidance. Additional information and clarification was requested by CNSC staff on June 18, 2018[26], which was provided by SRBT on July 4, 2018[27]. Based upon this information, all comments were deemed to have been addressed, save for a request that SRBT further revise the manual to account for the fact that 'grandfathering' of qualifications is not a current practice[28]. As a result, Revision D of the Training Program Manual was submitted to CNSC staff on September 19, 2018[29], and was accepted on October 5, 2018[30].

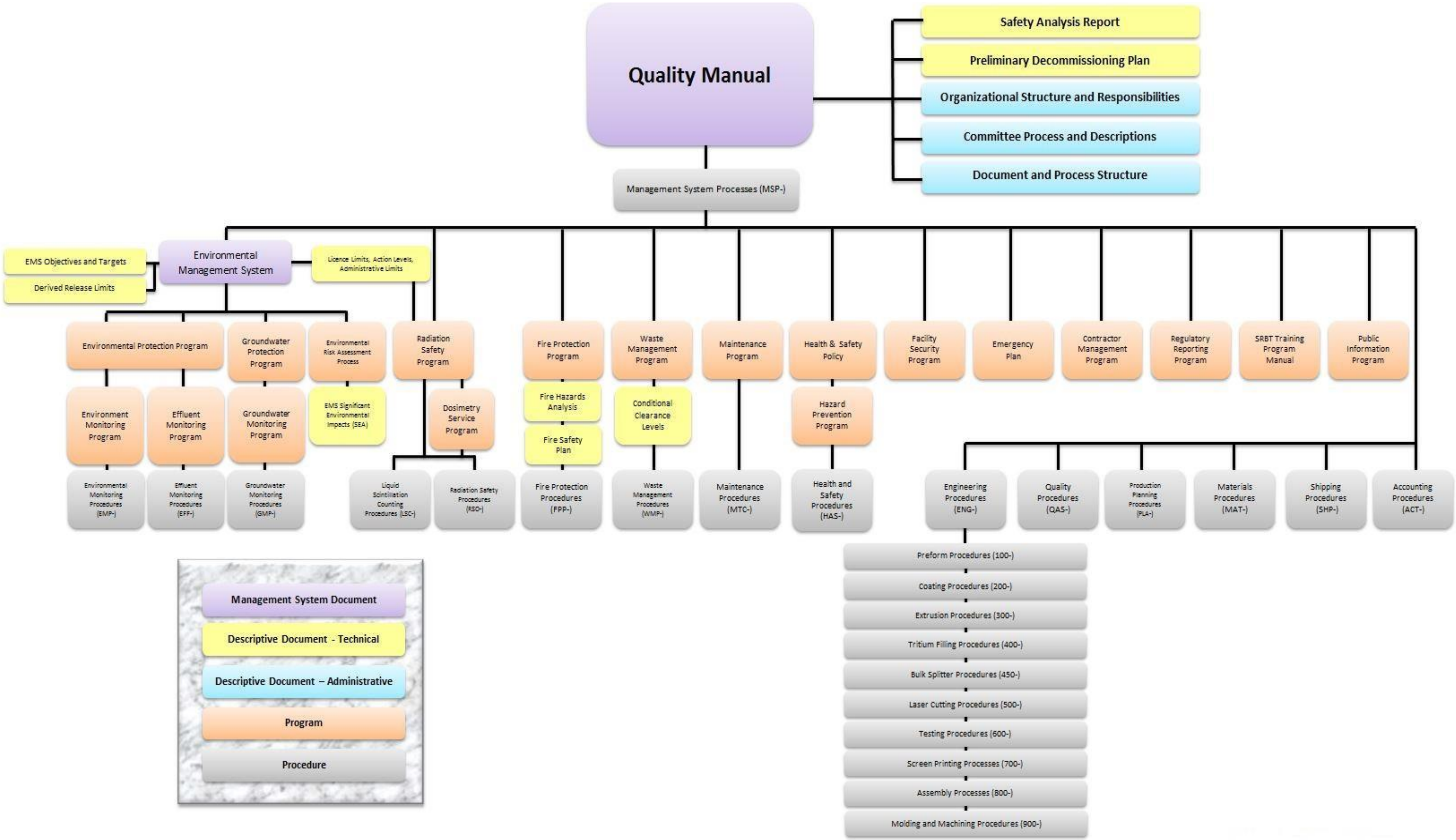
On August 24, 2018, Revision H of the **Waste Management Program** was submitted to CNSC staff for review and acceptance[31]. The program was revised to reflect changes in responsibilities, and to incorporate a modified conditional clearance level for the management of clearance-level waste. A comprehensive analysis of the proposed new clearance levels accompanied the submission which demonstrated that no new or additional risks were likely should the new clearance levels be implemented. CNSC staff accepted the revised program on October 5, 2018[32], noting that the clearance level remained unchanged with regards to total annual activity, and that the assumptions used in the dose calculations in the assessment continued to be valid and conservative.

SRBT submitted a revised **Fire Protection Program** and **Fire Safety Plan** to CNSC staff on September 19, 2018[33]. These revisions were made to include records of training for in-house inspections, and to reflect the updated membership of the Fire Protection Committee, as well as updates to processes and procedures. Both documents were accepted by CNSC staff on November 8, 2018[34].

2.1.7.2 SRBT Management System Document Hierarchy

Figure 2 illustrates the Management System document hierarchy in place as of the end of 2018.

FIGURE 2: MANAGEMENT SYSTEM DOCUMENTS



2.1.7.3 Procedures

In 2018, a total of 60 Engineering Change requests (ECR) were filed relating to procedural changes in the SRBT management system (compared to 76 in 2017). The breakdown of ECRs filed was as follows:

TABLE 3: PROCEDURAL ECR SUMMARY

PROGRAM / AREA	NUMBER OF ECRs
MANAGEMENT SYSTEM	8
RADIATION SAFETY	7
PRODUCTION	7
WASTE MANAGEMENT	6
QUALITY	5
CONVENTIONAL HEALTH AND SAFETY	4
ENVIRONMENTAL MONITORING AND PROTECTION	4
LIQUID SCINTILLATION COUNTING LAB	4
MAINTENANCE	4
EFFLUENT MONITORING	2
FIRE PROTECTION	2
SHIPPING AND RECEIVING	1
WORK PLANNING	1
OTHER	5
TOTAL	**60**

Note that where appropriate, one ECR may encompass more than one procedural improvement.

Procedural changes were implemented for a variety of purposes. Many improvements have been incorporated as a result of the continuing, expanded oversight provided by SRBT's internal audit processes, as well as a dedicated managerial focus on improvement initiatives in each area.

2.2 SCA – Human Performance Management

Throughout the course of 2018, SRBT ensured that at all times a sufficient number of qualified workers were available to carry out licenced activities in a safe manner, and in accordance with the NSCA and associated regulations.

In 2018 our staff complement fell by two employees; by the end of the year, SRBT employed a total of 42 staff members, compared to 44 staff members in 2017.

The average experience of our workforce stands just under 11 years, with an average age of just over 43 years old. The Health Physics Team possesses a combined 135 years of work experience with the company, while production supervisors average just over 19 years of experience with SRBT.

Careful consideration continues to be taken when appointing new staff to ensure continued nuclear safety.

The activities of four work areas (marked in yellow in Table 4) do not involve tasks that affect nuclear safety. Generally employees hired as Production Technicians are first appointed to one of these five work areas. These positions do not in any way impact the company's ability to ensure that the requirements of the Nuclear Safety and Control Act, Regulations and conditions of the licence[1] and LCH[2] are met.

TABLE 4: NUCLEAR SAFETY TASKS PERFORMED PER WORK AREA

WORK AREA	AVERAGE EXPERIENCE (IN YEARS)	RESPONSIBLE FOR PROGRAMS AND PROCEDURES THAT AFFECT NUCLEAR SAFETY	PROCESS TRITIUM	HANDLE SEALED TRITIUM SOURCES
ADMINISTRATION	**15.34**	✓	-	-
RIG ROOM	**12.88**	-	✓	✓
GLASS SHOP	**12.25**	-	-	-
ASSEMBLY	**6.16**	-	-	✓
MACHINING AND MOLDING	**9.77**	-	-	-
COATING	**7.64**	-	-	-
SHIPPING	**5.05**	-	-	-

The Rig Room is the department where tritium processing takes place, and has the highest average work experience with the company of any production department. The average work experience of the staff within this department is just under 13 years.

The Supervisor and another employee in this department have over 27 years of experience and perform or oversee all activities that involve tritium processing or handling of tritium sources.

The Assembly Department is where tritium sources are handled by staff for assembly into products or for packaging. The tritium is contained in the source at this stage and the possibility of tritium exposure is low. The Supervisor in this department has over 19 years of experience and performs or oversees all activities of other staff members.

2.2.1 Training

2.2.1.1 Annual All-Staff Training Session

Once per calendar year, SRBT shuts down all manufacturing operations in order to conduct an all-day, all-staff training session.

The agenda for this training traditionally incorporates a wide variety of aspects of our operations. The majority of the day is dedicated to a refresher course in radiation protection, specifically oriented at the unique type of hazard present at SRBT.

This training was conducted on December 11, 2018, and included information with respect to natural radiation exposure, anticipated health effects from radiation exposure, tritium, proper handling of tritium throughout the facility, and equipment for personal radiation protection purposes.

As well, training is provided to all staff on fire safety, security, our supervisory awareness program, and the SRBT Workplace Hazardous Information Management System (WHMIS).

An information session was also conducted focused on work-level appropriate aspects of the SRBT Management System, including the management system processes for change control, non-conformances and opportunities for improvement.

Specific information on the radiation safety training provided by SRBT can be found in section 4.1, ‘SCA - Radiation Protection’.

2.2.1.2 Fire Extinguisher Training

Annual fire extinguisher training was conducted with the support of the Pembroke Fire Department on October 31, 2018. As in past years, the training was conducted using an electronic simulator, eliminating the risks associated with the controlled, repeated burning and extinguishing of liquid hydrocarbons as an environmentally-friendly measure.

The training also included a classroom-based session discussing personal safety when detecting a fire, the types of extinguishers available in the facility, and the proper and safe use of extinguishers when fighting fires.

2.2.1.3 Fire Protection Specialist Training

In August, the Fire Protection Specialist attended a 3-day hands-on training course focused on NFPA 13, *Standard for the Installation of Sprinkler Systems.*

In October, the Fire Protection Specialist attended a 3-day hands-on training course focused on NFPA 25, *Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems.*

Both of these training activities were hosted by the Seneca College School of Fire Protection Engineering Technology in Toronto, Ontario.

2.2.1.4 TDG Training

Transportation of Dangerous Goods (TDG) training for shipping department staff is scheduled every two years. The training is conducted by an outside agency with expertise in the transport of dangerous goods.

In line with the schedule of this training, a session was not conducted in 2018. Training is scheduled to be next held in 2019.

2.2.1.5 Health and Safety Training

The Manager - Safety and Security and an employee representative of the Health and Safety Committee attended a Health & Safety Training Conference in Ottawa on October 10, 2018, and took part in training seminars that included:

- A Day in the Life of a Supervisor in 2018
- Workplace Harassment and Violence – Bill C-65
- Update on the Laws of Drugs in the Workplace
- Removing the Mask – How to Respectfully Approach Employees Dealing with Mental Health Issues
- Eat, Sleep, Move – Eat Better, Move Better and Sleep Better

In December 2018, all SRBT staff were given refresher training in WHMIS at the annual SRBT training day.

2.2.2 Systematic Approach to Training Program

SRBT continues to implement a systematic approach to training (SAT) as part of our overall training program, and the Training Committee actively ensures that the processes described in the Training Program Manual are managed effectively and improved on an ongoing basis. In early 2018, SRBT achieved the goal of all seven originally categorized SAT-based activities being fully implemented.

Three meetings of the Training Committee were held in 2018, with the annual program evaluation being held in April, and both the annual focused discussion on training change management, and the annual review of the qualification of SAT-based trainers being conducted in November.

Four new activities were brought to the Training Committee for a categorization decision during the year. Two activities were determined to be eligible for management as Category 1 training activities (non-SAT based), while one activity was withdrawn before the review took place. The fourth activity is slated for review at the first meeting of the committee in 2019.

Qualification management processes continue to ensure that SAT-qualified staff members maintain their skills through frequency of performance requirements, and that the qualification of SAT-based trainers continues to be evaluated periodically.

A total of ten individual workers are qualified (or are in the process of qualification) in at least one of the seven SAT-based activities developed and implemented. This includes production technicians who perform tritium processing operations, as well as members of the Health Physics Team.

The following table compiles the status of training or workers in SAT-based activities at the end of 2018.

TABLE 5: WORKER QUALIFICATION IN SAT-BASED ACTIVITIES

SAT Work Activity	Fully Qualified Workers	Workers Progressing Toward Full Qualification
SAT-HP-01: ADVANCED HEALTH PHYSICS INSTRUMENTATION	2	1
SAT-HP-02: LIQUID EFFLUENT MANAGEMENT AND CONTROL	4	0
SAT-HP-03: WEEKLY STACK MONITORING	4	1
SAT-HP-04: BIOASSAY AND DOSIMETRY	3	2
SAT-OP-01: TRITIUM PROCESSING – FILLING AND SEALING LIGHT SOURCES	5	0
SAT-OP-02: BULK SPLITTER OPERATIONS	3	1
SAT-OP-03: HANDLING PUTTS	4	0

2.3 SCA – Operating Performance

SRBT has continued to operate the facility safely and in compliance with our operating license throughout 2018.

Our programs and processes have continued to evolve to meet or exceed regulatory requirements and expectations, with safety as an overriding priority in all aspects of our licensed activities.

A summary of compliance with operational limits and conditions can be found under section 1.3 of this report.

A summary of annual production / utilization data can be found in section 1.4 of this report.

A description of the internal and external audits conducted relating to licensed activities can be found under sections 2.1.4 and 2.1.5 of this report.

2.3.1 Ratio of Tritium Released to Processed

In 2018 our team continued to strive to minimize the amount of tritium released to the environment for every unit of tritium processed – we refer to this as the 'released to processed' ratio. This ratio is an excellent indicator of the overall effectiveness of our emission reduction initiatives.

The following table illustrates how this ratio has trended over the past five years.

TABLE 6: TRITIUM RELEASED TO PROCESSED RATIO (2014-2018)

DESCRIPTION	2014	2015	2016	2017	2018
TOTAL TRITIUM RELEASED TO ATMOSPHERE (GBq/YEAR)	66,161	56,237	28,945	24,822	33,180
TRITIUM PROCESSED (GBq/YEAR)	28,714,119	27,989,832	28,122,678	32,968,695	31,251,329
RELEASED / PROCESSED (%)	**0.23**	**0.20**	**0.10**	**0.08**	**0.11**
CHANGE IN RATIO INCREASE (+) / REDUCTION (-)	-12%	-13%	-50%	-20%	+38%

The increase in the ratio of tritium released to processed is likely due to several factors; however, the most significant influence is likely an increased rate of production during summer months due to the issues with shipping containers for bulk tritium (see section 1.2.7).

Operations during warm, humid days can have a significant effect on the amount and form of tritium being released via gaseous effluent. This effect had the most significant impact on our emissions profile for 2018, as a higher rate of light source production was required between June through September in order to recover from the production throttling in May, as well as to accommodate an increased order book.

Despite these challenges, the ratio of gaseous emissions experienced in 2018 remained within expected operational variance with no action level exceedances, and we were still able to achieve the target set for this ratio at the start of 2018 (target of 0.13% vs. achievement of 0.11%).

2.3.2 Objectives and Targets

SRBT performance against key objectives and targets for 2018 is tabled below.

TABLE 7: 2018 PERFORMANCE TARGETS

DESCRIPTION	2018 TARGET	PERFORMANCE
MAXIMUM DOSE TO NUCLEAR ENERGY WORKER	≤ 0.75 mSv	0.48 mSv
AVERAGE DOSE TO NUCLEAR ENERGY WORKER	≤ 0.060 mSv	0.044 mSv
CALCULATED DOSE TO MEMBER OF THE PUBLIC	≤ 0.0060 mSv	0.0038 mSv
WEEKLY AVERAGE TRITIUM RELEASES TO ATMOSPHERE	≤ 650 GBq	Average = 638 GBq 20 weeks > Target
RATIO OF TRITIUM EMISSIONS VS. PROCESSED	≤ 0.13%	0.11%
TOTAL TRITIUM EMISSIONS LIQUID EFFLUENT PATHWAY	≤ 7 GBq	10.02 GBq
ACTION LEVEL EXCEEDANCES ENVIRONMENTAL	≤ 1	0
ACTION LEVEL EXCEEDANCES RADIATION PROTECTION	≤ 1	0
CONTAMINATION CONTROL FACILITY-WIDE PASS RATE	≥ 95%	94.7%
LOST TIME INJURIES	0	0
MINOR INJURIES REPORTABLE TO ESDC	≤ 20	15

An assessment of the apparent causes of the missed targets for both liquid effluent and facility contamination control pass rate will be conducted and discussed during committee meetings and management review in early 2019.

2.3.3 Reported Events

In line with our Regulatory Reporting Program, SRBT reported one event to CNSC staff in 2018.

Incorrect Package Categorization

On February 5, SRBT offered a tritium storage container for transport that was later found to have contained a Type ‘B’ quantity of tritium in a package categorized as Type ‘A’.

SRBT offered the package for transport to Canadian Nuclear Laboratories (CNL) from our facility in Pembroke. The package was transported by CNL carrier to their facilities that same day.

Twenty-three days later, on February 28, SRBT was notified by the consignee that after conditioning of the tritide storage container, a volumetric quantity of gas was recovered which exceeded the Type ‘A’ quantity limits. As such, the shipment conducted on February 5 should have been classified as UN2916 (Type ‘B’) rather than UN2915 (Type ‘A’).

The package used to transport the tritide bed was the CNL 2060 ‘Tritide’ package, certified to transport up to 18,500 TBq, under certificate CDN/2060/B(U)-85 (Rev. 6).

The package had been assembled and tested to specification as if it contained a Type ‘B’ quantity; however, the labelling and accompanying transport documents classified the shipment as UN2915, Type ‘A’. The quantity of tritium contained in the package exceeded the Type ‘A’ limit of 40 TBq by a slight margin, but was well within the limit of the package as assembled and tested.

In order to prevent this type of administrative event from recurring in the future, SRBT has ceased shipping these containers as a Type ‘A’ quantity in a Type ‘B’ package, and instead now conservatively ship it labelled and documented as a Type ‘B’ shipment (UN2916).

The full report of this event[35] was provided to CNSC staff on March 14, 2018, with CNSC staff concluding that our actions were adequate[36] on March 16, 2018.

2.3.4 Inventory Control Measures

2.3.4.1 Tritium

SRBT has continuously possessed, transferred, used, processed, managed and stored all nuclear substances related to the operation of our facility in compliance with the requirements of our licence.

A number of inventory control measures are in place to ensure that tritium on site does not exceed the possession limit prescribed by our operating licence.

The maximum amount of tritium possessed by SRBT at any one time during 2018 was 4,531 TBq, or approximately 76% of our possession limit. The average monthly inventory on site was 3,683 TBq.

Tritium on site is found in:

- Bulk containers and tritium traps,
- New light sources,
- The exit signs for our facility,
- New product that contain light sources,
- Work in progress,
- Waste,
- Expired light sources taken out of product,
- Products that contain expired light sources, and
- Non-conforming product

Refer to **Appendix A** for additional details on tritium inventory in 2018.

2.3.4.2 Depleted Uranium

SRBT possessed a reported 5.57 kg of depleted uranium in metallic form at the beginning of 2018. This material is used for tritium traps as part of the production of gaseous tritium light sources.

The inventory of material changed three times in 2018:

- As a result of a physical inventory assessment, the total inventory on site was adjusted by 4 grams in May, due to the identification and removal of several very small pebbles of other minerals in the stored material on hand.
- In August, a waste shipment of tritium trap bases that had reached their usage limit was performed. A total of 886 grams of depleted uranium was sent off site to a licensed waste management service provider.
- In October, new ‘virgin’ depleted uranium pellets were procured and delivered to the facility. A total of 5,000 grams of material was brought into the facility.

At the conclusion of 2018, the total mass of depleted uranium on site stands at 9.678 kg. A limit of 10 kg of this material in inventory is applied as part of the operating limits and conditions in the SAR.

The breakdown of this inventory is as follows:

TABLE 8: DEPLETED URANIUM INVENTORY BREAKDOWN AT THE END OF 2018

QTY	DESCRIPTION	DEPLETED URANIUM IN EACH (GRAMS)	TOTAL DEPLETED URANIUM (GRAMS)
1	LOOSE FORM – CONTAINER 1	N/A	2,428
1	LOOSE FORM – CONTAINER 2	N/A	4,973
9	ACTIVE P.U.T.T.	30 +/- 5	267
3	NON-ACTIVE P.U.T.T.	30 +/- 5	90
6	AMERSHAM CONTAINERS	320	1,920
		TOTAL	**9,678**

2.3.5 Liquid Scintillation Quality Assurance and Control

2.3.5.1 Routine Performance Testing

Routine Performance Testing is performed on both liquid scintillation counters on a quarterly basis, as required in section 4.2.3 of CNSC Regulatory Standard S-106, *Technical and Quality Assurance Requirements for Dosimetry Services* (Rev. 1).

Routine Performance Testing is performed to specifically demonstrate that liquid scintillation counting assays, including those conducted in support of the dosimetry service, are operated in a predictable and consistent way.

The testing was carried out every 3 months as required throughout 2018 on each of the two 'TriCarb 2910' units, with no failures reported.

2.3.5.2 Weekly LSC Performance Check

SRBT quality assurance requirements for liquid scintillation counting include weekly instrument performance checks using National Institute of Standards and Technology (NIST) traceable standards of a blank, H-3 and C-14 standards.

All tests have been performed on both TriCarb 2910 LSC units, and included an assessment of the instrument efficiency for tritium measurement, the figure of merit, the tritium background measurement, and a chi-square test. An instrument must meet acceptability criteria on a weekly basis, or the unit is removed from service pending corrective maintenance or actions.

2.3.5.3 Assay Quality Control Tests

NIST-traceable reference standards are prepared in-house, and are analyzed and checked against quality control acceptance criteria with every batch of liquid scintillation counting samples being analyzed.

All tests were performed as required with every assay throughout 2018, in order to ensure quality control of LSC laboratory processes.

3. Facility and Equipment SCAs

3.1 SCA – Safety Analysis

Our operating practices and processes in 2018 have continued to be conducted in full alignment with the latest version of SRBT's Safety Analysis Report (SAR).

CNSC staff formally accepted Revision 4 of the SAR on January 12, 2018, after SRBT made several changes and updates to Revision 3 in the fourth quarter of 2017 based on regulatory feedback.

There were no changes to the facility or our operations that had any direct bearing on the safety analysis in 2018.

Please refer to section 1.3 of the report for a complete breakdown of SRBT compliance against the Operating Limits and Conditions in the SAR.

In summary, the overall safety case for SRBT continues to be effectively validated and maintained. As always, SRBT will continue to respond to events in the nuclear industry and beyond that could influence or otherwise affect our safety analysis.

It is not expected that our facility, our licensed activities or our processes will change significantly over the coming years; however, SRBT will continue to manage and improve the SAR in line with our management system processes. As per the Licence Conditions Handbook (LCH), condition 5.1, compliance verification criterion 2, the SAR is next due for scheduled periodic review in 2022.

3.2 SCA – Physical Design

As a manufacturing company, SRBT owns and operates several pieces of equipment, several of which constitute structures, systems and components (SSCs) which have a bearing on safety and our licensed activities.

Such equipment includes the active ventilation systems and associated emissions monitoring equipment, fire detection and suppression systems, tritium processing rigs, tritium-in-air monitors, and liquid scintillation counters.

The overall facility design is also a key aspect of our operations, and must be managed and controlled safely. The SRBT change control process helps to ensure that modifications are controlled, reviewed, accepted, and recorded using an Engineering Change Request (ECR).

All significant modifications to structures, systems and components associated with our licensed activities were conducted in accordance with our change control processes.

Two relatively minor changes in physical design of important facility systems or components took place in 2018, as described in the following sections. These changes did not result in a negative impact on the ability of the facility and SSCs to meet and maintain their design function, and were within the licensing basis.

3.2.1 Addition of Tritium Trap Connection Points to Bulk Splitting Rig

When not in use, tritium traps are evacuated of all air and then valved shut, in order to prevent air or moisture from interacting with the depleted uranium tritide in the trap. Any air introduced into the tritium trap can lead to shortened component life and increased tritium emissions over time.

Ideally, the trap should remain connected to processing equipment that has also been pumped down to the lowest achievable vacuum pressure, in order to further reduce the potential for air in-leakage should the trap valve not form a perfect seal.

When a trap is connected to light source filling rigs, these conditions are met. The bulk splitting rig had three functioning connection points with plumbed vacuum service for traps and/or a bulk tritium container; as such, this typically means that there are two available connection points for traps on the bulk splitting rig, as usually a bulk container is also kept connected.

With five operating light source filling rigs, a total of seven vacuum-serviced connection points were available for what is usually nine in-service tritium traps.

A design change was proposed and processed through ECR-833, to add two additional vacuum-serviced connection points to the bulk splitting rig, in order to ensure all tritium traps can be connected to a pumped-down line when not in use.

The physical change to the bulk splitting rig was completed in May, and has been effective at achieving the intended goal of adding defense in depth in the design of our processing systems.

3.2.2 Configuration Change of Zone 1/2 Barrier

The facility incorporates three radiological zones as part of the Radiation Safety Program, in order to minimize the spread of tritium contamination.

There are two primary transition points between zones in the facility. One of these points is at the entryway to the Assembly area, which is classified as a Zone 2 area in the program.

In order to improve the layout of the transition point, the barrier that separates the two zones was improved in 2018. The area on the Zone 1 side of the transition point was slightly expanded to allow for more freedom of movement of persons transitioning over the barrier, as well as ensuring ample work space is made available for processes on both sides of the barrier. As well, wooden cabinetry was removed and replaced with new metal storage space, in line with fire protection improvement initiatives.

The change was controlled through ECR-759, and the new zone layout was implemented in May. The change has been effective at achieving its intended goals.

3.3 SCA – Fitness for Service

All equipment, including all safety-related equipment, is kept in a condition that is fit for service through the implementation of the Maintenance Program. The facility and equipment associated with the facility were effectively maintained and operated within all manufacturer requirements.

Note that, although the Maintenance Program incorporates several program elements associated with nuclear power plants as best practice (such as critical spares, master equipment lists, etc.), aging management is not an element that is formally included as a strategy.

In 2018 there were no significant equipment failures that presented a safety concern, demonstrating the effectiveness of the Maintenance Program implemented by SRBT.

Documented maintenance meetings were initiated and held by the Maintenance Committee throughout 2018. As part of management review processes, an annual review of 2018 activities will be conducted in the first quarter of 2019, including data pertaining to equipment failures, maintenance activity success rates, non-conformances, procedural revisions, and audit findings.

Maintenance records are kept on file including completed work orders of preventative maintenance activities. A maintenance schedule is created and managed by the Project Engineer, and effectively captures all safety-significant planned preventative maintenance activities, whether performed by SRBT personnel or an approved contractor, and includes maintenance inspections as required by the Fire Protection Program. As well, corrective maintenance was tracked, trended and reviewed to assess the performance of equipment, and to identify any preventative activities which may improve performance.

Preventative maintenance was scheduled and performed in 2018 on equipment as per **Appendix B** of this report.

The fitness for service of key individual structures, systems and components are summarized below:

3.3.1 Ventilation

The ventilation of the facility is such that the air from the facility flows to the area with greatest negative pressure in Zone 3 which has the highest potential for tritium contamination where all tritium processing takes place. This area and part of Zone 2 are kept at high negative pressure with the use of two air handling units which combined provide airflow of approximately 10,000 cubic feet per minute.

The air handling units are connected to a series of galvanized stainless steel ducts. In addition to providing ventilation for the facility these air handling units also provide local ventilation to a number of fume hoods which are used to perform activities that have a potential for tritium contamination and exposure.

All ventilation systems were maintained fit for service throughout 2018. Corrective and preventative maintenance was identified and performed according to the requirements of the Maintenance Program and operational procedures. Key equipment is maintained either on a quarterly or semi-annually basis, with most equipment maintenance being performed under contract with a fully licensed maintenance and TSSA-certified local heating, ventilation and air conditioning (HVAC) contract provider.

A listing of the ventilation equipment maintained in 2018 can be found in **Appendix C** of this report.

3.3.2 Stack Flow Performance

Stack maintenance is performed by a third party, in order to ensure effective performance of the ventilation system and minimize airflow reductions from the beginning to the end of the maintenance cycle to ensure accuracy of results.

Pitot tubes that were installed in the stacks are maintained by a third party to ensure stack airflow are at design requirements. This essentially allows for daily stack flow verification in addition to more detailed annual stack flow verification performed by a third party.

The annual stack flow performance verification was performed on September 27, 2018 by a third party. The inspection confirmed that the stacks continue to perform to design requirements. SRBT continues to monitor and trend the results of the annual stack performance verification.

3.3.3 Liquid Scintillation Counters

The two TriCarb 2910 liquid scintillation counters (LSC) were subjected to an annual preventive maintenance procedure on October 16, 2018. No significant concerns or issues were identified during the maintenance activity.

Two instances of corrective maintenance on a counter took place; a rack-jamming issue was corrected on January 23, 2018, and an elevated background problem was addressed on June 8, 2018. The issues and maintenance corrections had no bearing on measurements of tritium previously performed.

Both systems will continue to be preventively maintained and calibrated on an annual basis by a qualified service representative from the manufacturer of the equipment, to ensure their functionality, accuracy and reliability.

3.3.4 Portable Tritium-in-Air Monitors

Portable tritium-in-air monitors are maintained and made available throughout the facility. The portable units are used to investigate potential sources of tritium leakage, and for personnel protection.

Six of these monitors are used at the facility (one in Zone 1, two in Zone 2 and three in Zone 3), while the seventh is kept on emergency standby at the Pembroke Fire Hall as part of an emergency preparedness kit.

As required by our Radiation Safety Program, all in-service tritium-in-air monitors were calibrated and maintained at least once during 2018, with all records of the maintenance are kept on file.

3.3.5 Stationary Tritium-in-Air Monitors

The ambient air in selected key areas of the facility is continuously monitored using stationary tritium-in-air monitors.

There continues to be five stationary tritium-in-air monitors deployed for airborne tritium monitoring at the facility. These monitors operate 24 hours a day to ensure that any upset conditions are identified and addressed quickly. As an improvement initiative, in 2018 SRBT procured an additional stationary monitor, increasing the number of units available on standby as a spare from one to two.

Three monitors are strategically located in Zone 3; one in the Rig Room where gaseous tritium light sources are filled and sealed; one in the Laser Room where a laser is used to cut and seal small gaseous tritium light sources, and light sources are inspected; and one in the Tritium Laboratory where tritium is transferred from bulk supply containers to filling containers.

One stationary tritium-in-air monitor is located in Zone 2 in the Assembly Area, where gaseous tritium light sources are pre-packed in preparation for shipping or installed into device housings.

A stationary tritium-in-air monitor is located in the shipping area in order to provide an early warning signal of a problem should a light or device be damaged during packaging activities.

As required by our Radiation Safety Program all tritium-in-air monitors were calibrated and preventively maintained at least once during 2018. All five facility monitors functioned effectively and continuously throughout the year, with all records of maintenance retained on file.

3.3.6 Stack Monitoring Equipment

Stack monitoring equipment is incorporated for each of two main air-handling units. For each air-handling unit, the monitoring equipment includes:

- A tritium-in-air monitor connected to a real-time recording device,
- An alarming remote display unit (RDU) in Zone 3,
- A bubbler system for discriminately collecting HTO and HT in the sampled stream of effluent,
- A flow measurement device with elapsed time, flow rate and volume of the sampled stream of effluent, and
- A dedicated back-up power supply servicing the monitors, bubbler systems and flow meters, capable of providing several hours of uninterrupted power to the equipment during a power failure.

Each tritium-in-air monitor is connected to real-time recording devices (chart recorders), and was calibrated and preventively maintained as required in 2018.

The chart recorders (analog and digital), tritium monitors and RDUs are included in calibration verification activities on a quarterly basis. Bubbler systems (and spare systems) were also maintained throughout the year, with a bi-monthly maintenance cycle being implemented on all in-service stack monitoring equipment.

In 2018, two of the four bubbler systems were sent out to the original manufacturer to undergo refurbishment as a preventative maintenance activity. Each unit was retrofitted with a new sampling pump, catalytic oven, band heater, thermocouple, filter package, three-way solenoid valve and bottle holder O-rings, and was also air flow calibrated. This activity will help ensure the availability of accurate monitoring equipment at all times for the foreseeable future.

As the calibration of the bubbler sample flow measurement devices is only valid for one year, each device is replaced with a newly calibrated unit on an annual basis. Four newly calibrated units were placed into service rotation on April 24, with the four units with expiring calibration validity being removed from service, and sent out for third party calibration in November 2018.

Three instances of corrective maintenance on a component of the stack monitoring equipment were performed in 2018, all dealing with issues on the digital chart recorder.

On April 30, 2018, a Rig Room production technician noticed that the digital chart recorder was not responding as expected when purging rigs. The RDUs and the paper chart recorder were all functioning correctly. It was discovered that one of the wires on the connector on the chart recorder had become loose. The wire was reattached and tightened, and the chart recorder function checked and confirmed as responding correctly.

The chart recorder data was reviewed and it was determined that the disconnection occurred at 1518h on April 24. The TAMs, paper chart recorder and RDU were not affected by the disconnected wire, and no data on emissions was lost as a result. It was determined that the wire had likely come loose when installing a new metal cabinet in the area, which had required the physical movement of the placement of the chart recorder. A non-conformance report was raised to document the issue, and drive corrective actions.

On August 30, 2018, the electronic chart recorder display was noted to be fragmented and greyed out, with an accompanying audible alarm. The unit was removed from service and sent to the manufacturer, which diagnosed a failed internal power supply. An internal corrective maintenance record was created in line with Maintenance Program requirements.

The unit was repaired and returned to SRBT on September 10, and subsequently tested and put back into service. The analog / paper chart recorder continued to record tritium emissions in real time throughout the time period where the electronic chart recorder was out of service. As well, in response to this event, a spare electronic chart recorder was procured and delivered to SRBT in October.

When checking the stack monitoring chart recorders on November 14, 2018, it was noted that the pen for the bulk stack on the electronic chart recorder was behaving erratically, with measurements 'bouncing' between 15 - 50 µCi/m^3. It was found that a loose connection had developed on the signal wire connection point, which was quickly corrected. The wire was likely loosened after the chart recorder was touched inadvertently during daily janitorial work. In order to drive corrective actions, a non-conformance report was raised to document the issue.

3.3.7 Stack Monitoring Verification Activities

The annual verification activity for the bubbler systems was performed in February 2018, where independent third party measurements provided validation that SRBT bubblers continue to effectively measure weekly gaseous tritium emissions (both HTO and HT).

All results measured and derived by the third party were within the acceptance criteria of +/- 30% of SRBT measurements for both tritium forms, from both active ventilation trains.

3.3.8 Weather Station

Maintenance of the weather station is performed as per the manufacturer’s recommendation, every two years.

Maintenance of the weather station was performed on June 29, 2018. It is next scheduled to be performed in 2020.

3.3.9 Air Compressor

Process tasks at SRBT require the use of a compressed air system. The air compressor is subject to quarterly preventative maintenance activities, and semi-annual belt changes, all of which were carried out throughout 2018.

4. Core Control Processes SCAs

4.1 SCA – Radiation Protection

4.1.1 Dosimetry Services

During 2018, SRBT maintained a Dosimetry Service Licence (DSL), for the purpose of providing in-house dosimetry services for the staff of SRBT and contract workers performing services for SRBT where there existed potential exposure for uptake of tritium. The licence was renewed on June 1, 2018 for a period of ten years, and SRBT has implemented a dedicated Dosimetry Service Program in support of compliance with the requirements of this licence.

All dosimetry results were submitted on a quarterly basis to Health Canada in a timely fashion for input to the National Dose Registry. A final annual report was also submitted as required. A total of 47 individual staff members were included in National Dose Registry (NDR) reports at some point in 2018.

SRBT participated in the annual Tritium Urinalysis Performance Test sponsored by the National Calibration Reference Centre for Bioassay, Radiation Surveillance and Health Assessment Division, Radiation Protection Bureau of Health Canada. The participation is a regulatory requirement for Dosimetry Service Providers.

SRBT received the Certificate of Achievement for successful participation in the Tritium Urinalysis Performance Test from the National Calibration Reference Centre for Bioassay and In Vivo Monitoring for the year 2018[37].

SRBT also submitted an Annual Compliance Report to CNSC Dosimetry Services Specialists for the Dosimetry Service Licence[38].

4.1.2 Staff Radiation Exposures and Trends

Through the Dosimetry Service Licence 11341-3-28.0, SRBT assesses the radiation dose to its employees and to contract workers who may have exposure to tritium.

All SRBT staff members are classified as Nuclear Energy Workers and participate in the dosimetry program.

Persons who work in Zones 1 and 2 provide bioassay samples for tritium concentration assessment on a bi-weekly frequency due to the very low probability of uptake of tritium. Persons assigned to work in Zone 3 provide bioassay samples on a weekly frequency due to the higher probability of chronic uptake of tritium.

There were no occurrences of any personnel contamination events in 2018.

The assessment of dose to personnel, due to tritium uptake, is performed in accordance with the Health Canada Guidelines for Tritium Bioassay and CNSC Regulatory Standard S-106, *Technical and Quality Assurance Requirements for Dosimetry Services* (Rev. 1).

The maximum effective dose received by any person employed by SRBT in 2018 was 0.48 mSv, a value which is well within the regulatory limit for a nuclear energy worker of 50.0 mSv per calendar year.

The average effective dose all staff was calculated to be 0.044 mSv, while the collective dose continued to be extremely low at 2.06 person·mSv (for 47 persons total).

The tables found in **Appendix D** of this report provide the radiological dose data for workers at SRBT for 2018, as well as a comparison of dosimetry results for the past five years (2014-2018).

4.1.3 Action Levels for Dose and Bioassay Level

Dose and bioassay tritium concentration action levels are defined in SRBT's 'Licence Limits, Action Levels and Administrative Limits document[39]. They are as follows:

TABLE 9: ACTION LEVELS FOR RADIATION PROTECTION

PERSON	PERIOD	ACTION LEVEL
NUCLEAR ENERGY WORKER	CALENDAR QUARTER	1.0 mSv
	1 YEAR	3.0 mSv
	5 YEAR	15.0 mSv
PREGNANT NUCLEAR ENERGY WORKER	BALANCE OF THE PREGNANCY	2.0 mSv

PARAMETER	ACTION LEVEL
BIOASSAY RESULT	1,000 Bq / ml FOR ANY PERIOD

In 2018 there were no exceedances of an action level for dose or bioassay tritium concentration at SRBT.

4.1.4 Administrative Limits for Dose and Bioassay Level

Dose and bioassay tritium concentration administrative limits are defined in SRBT's 'Licence Limits, Action Levels and Administrative Limits document[39]. They are as follows:

TABLE 10: ADMINISTRATIVE LIMITS FOR RADIATION PROTECTION

PERSON	PERIOD	ADMINISTRATIVE LIMIT
NUCLEAR ENERGY WORKER	CALENDAR QUARTER	0.75 mSv
	1 YEAR	2.25 mSv

PARAMETER	ADMINISTRATIVE LIMIT
BIOASSAY RESULT	500 Bq / ml FOR ANY PERIOD IN ZONE 3 100 Bq / ml FOR ANY PERIOD IN ZONE 1 OR 2.

In 2018, one exceedance of an administrative limit occurred relating to the bioassay tritium concentration measured in a worker.

A measurement of 128.61 Bq/ml was obtained from a sample submitted on November 5 by a worker who had been performing assembly activities in Zone 2; this value exceeded the administrative limit of 100 Bq/ml for such work.

An investigation was conducted which determined that the exceedance was likely a result of a light source which broke while being handled by the worker.

A non-conformance report was raised and appropriate actions were taken to correct the issue and prevent recurrence.

4.1.5 Contractor Dose

In 2018, SRBT did not employ contract staff to perform work that presented a significant radiological hazard.

Eleven screening bioassay samples were obtained and measured from contracted tradespersons who provided maintenance support in areas other than Zone 1. None of these samples exceeded our internal screening criteria requiring the calculation of effective dose.

To summarize, no contractor received a recordable dose due to activities performed at our facility in 2018.

4.1.6 Discussion of Significance of Dose Control Data

A tabular summary of effective dose metrics for 2018 is provided in **Appendix D.**

4.1.6.1 Maximum Dose

The maximum effective dose to any staff member in 2018 was 0.48 mSv. This individual works in Zone 3 and performs tritium processing operations in Zone 3 as their primary duty. In 2017 the maximum dose to a staff member was 0.46 mSv; this represents a 4% increase in the maximum dose to a worker in 2018. The maximum individual dose for the current five-year dosimetry period (January 1, 2016 – December 31, 2020) is also 0.48 mSv.

The increase in maximum dose is very slight, and within expected operational variance given the activities conducted during the year.

A maximum dose of 0.48 mSv represents the achievement of our internal target for 2018 of less than 0.75 mSv. This supports the conclusion that the Radiation Safety Program and the Health Physics Team are achieving a high level of performance, and that workers are properly and adequately trained in safely conducting activities that may pose a radiation hazard. As well, this marks the fourth year in a row where no SRBT worker received an effective dose in excess of 1 mSv, despite a consistently high rate of production throughput.

SRBT continuously strives to lower the maximum dose to workers by using several strategies, including ensuring that no one worker exclusively performs dose-intensive activities, frequent and routine use of portable tritium in air monitors during processing operations, and the continuous oversight of the Health Physics Team during key activities on the shop floor.

In 2018, the maximum dose to an employee working primarily in Zone 2 was 0.04 mSv, a value which is 0.02 mSv lower than the maximum dose to an employee working primarily in Zone 2 in 2017. This decrease is not viewed as a significant change year over year for the type of operations conducted in Zone 2.

The maximum dose to an employee working primarily in Zone 1 was 0.01 mSv, a value that is unchanged from the maximum dose to an employee working primarily in Zone 1 in 2017.

In 2018, the maximum dose to an employee working primarily in administration was 0.01 mSv, a value that is unchanged from the maximum dose to an employee working primarily in Zone 1 in 2017.

The maximum worker dose over the past eight years is trended below for comparison, as well as a distribution chart for worker doses in 2018:

FIGURE 3: MAXIMUM ANNUAL WORKER DOSE TREND

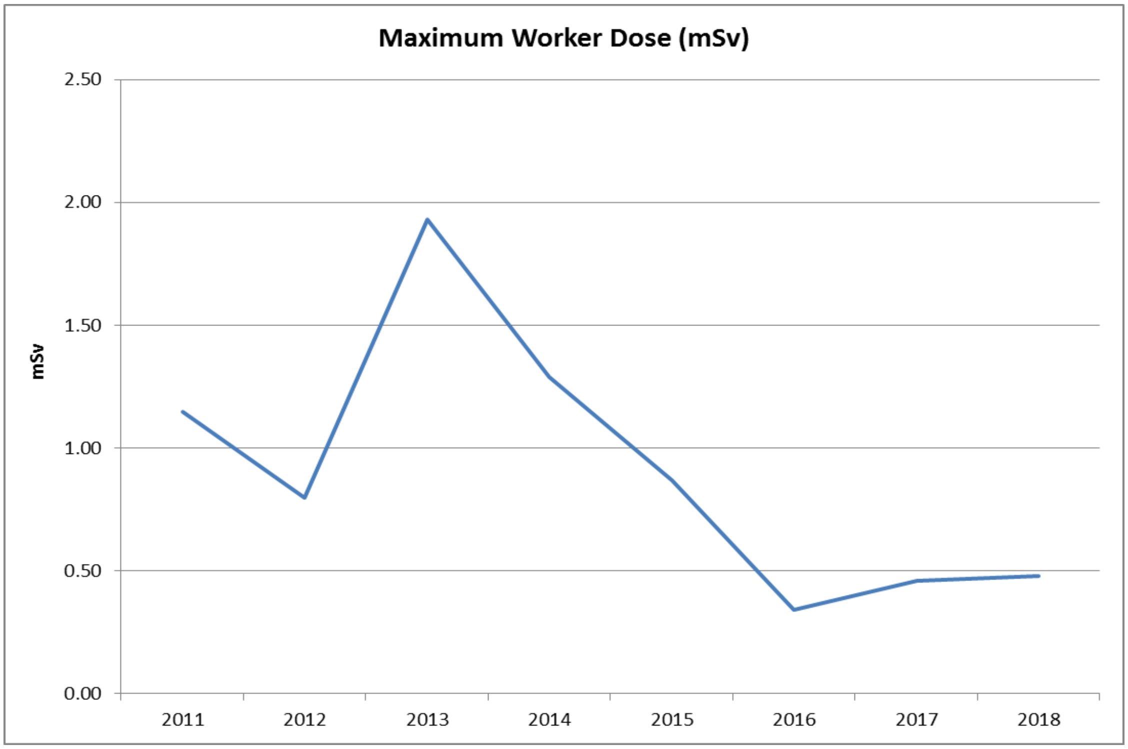
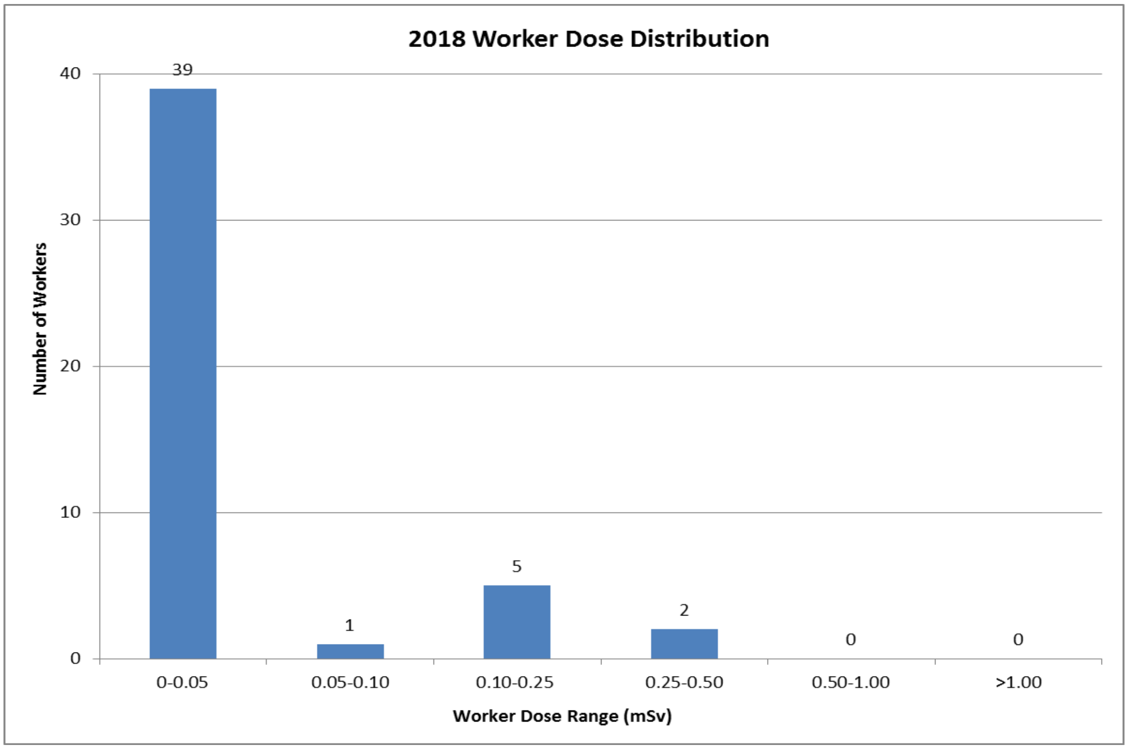


FIGURE 4: WORKER DOSE DISTRIBUTION



4.1.6.2 Average Dose

The average dose to workers at SRBT in 2018, including those workers whose dose value was zero, was 0.044 mSv.

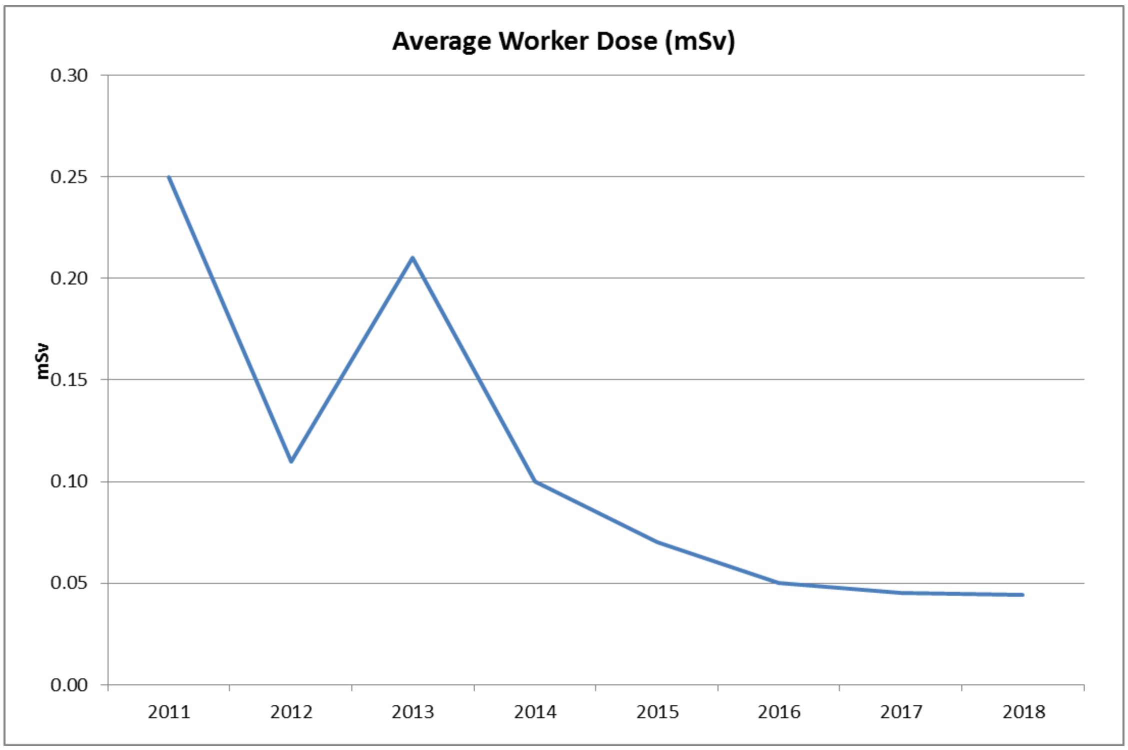
In 2017, this average was 0.045 mSv, thus 2018 represents a slight reduction in the average dose to staff.

This dose value is somewhat significant, as it is reliant not only on the radiation doses of individuals, but also the number of individuals working at SRBT.

A general trend can be taken over the past four years of data, as the total number of employees having worked or are working as NEWs during this time has been relatively stable, allowing for a direct comparison.

The average dose to workers at SRBT over the past eight years is trended below for comparison:

FIGURE 5: AVERAGE ANNUAL WORKER DOSE TREND



The average of all measurable doses, excluding workers with dose values of zero, was 0.09 mSv in 2018.

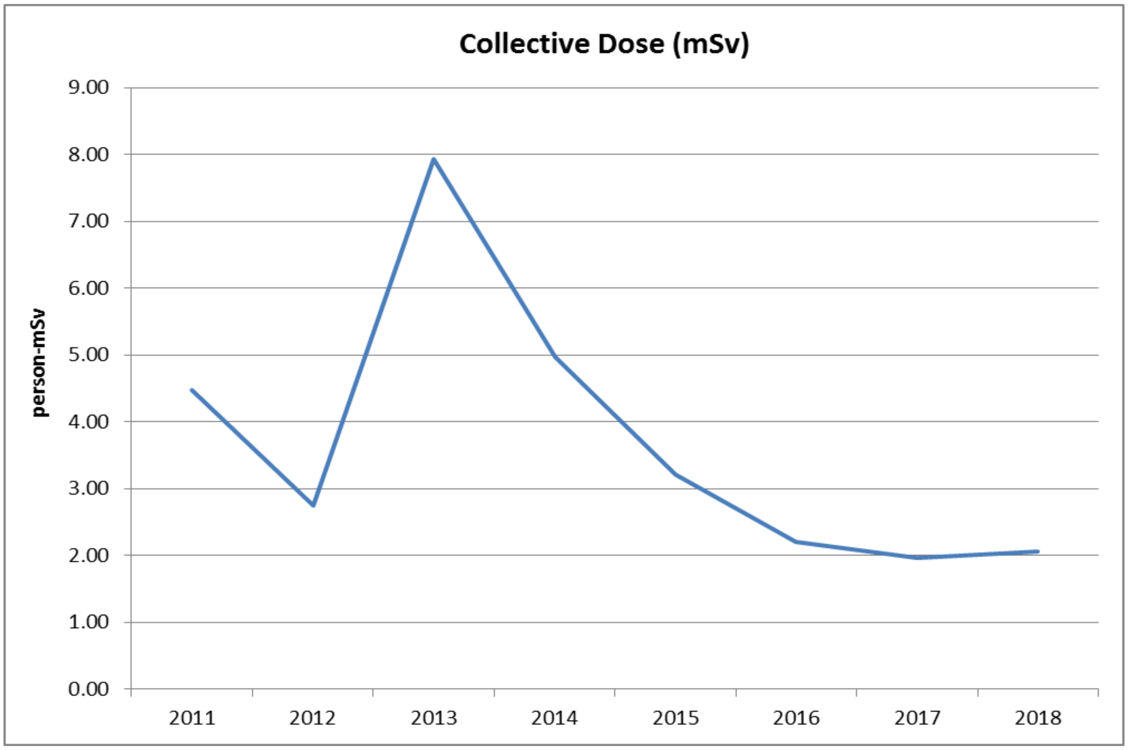
4.1.6.3 Collective Dose

The collective dose to workers at SRBT in 2018 was 2.06 person·mSv. In 2017, the collective dose was 1.96 person·mSv; the 2018 collective dose is thus approximately 5% higher than the year previous.

The stable level of collective dose, coupled with the generally stable number of active employees at any given time during the year is viewed as another significant data point that demonstrates the continued effectiveness of the Radiation Safety Program to protect workers and maintain radiation doses as low as reasonably achievable.

The collective dose to workers at SRBT over the past eight years is trended below for comparison:

FIGURE 6: COLLECTIVE DOSE TREND



4.1.7 Contamination Control and Facility Radiological Conditions

Tritium contamination control is maintained by assessment of non-fixed tritium contamination levels throughout the facility by means of swipe method and liquid scintillation counting of the swipe material. SRBT has in place the following administrative surface contamination limits:

TABLE 11: ADMINISTRATIVE LIMITS FOR SURFACE CONTAMINATION

ZONE	SURFACES	ADMINISTRATIVE SURFACE CONTAMINATION LIMITS
1	ALL SURFACES	4.0 Bq/cm^2
2	ALL SURFACES	4.0 Bq/cm^2
3	ALL SURFACES	40.0 Bq/cm^2

An overview of contamination monitoring results for 2018 has been tabulated and is included in **Appendix E** of this report. A total of 8,013 assessments were performed in various work areas in 2018.

A total of 500 swipes were taken in Zone 1 resulting in a pass rate of 97.0% below the administrative level of 4 Bq/cm^2.

A total of 1,728 swipes were taken in Zone 2 resulting in a pass rate of 93.2% below the administrative level of 4 Bq/cm^2.

A total of 5,785 swipes were taken in Zone 3 resulting in a pass rate of 94.9% below the administrative level of 40 Bq/cm^2.

All swipe results are reported to the area supervisors. The area supervisor and the Health Physics Team reviews the results to determine where extra cleaning effort is necessary. A comparison of the data for the last several years is presented:

TABLE 12: PASS RATE FOR CONTAMINATION ASSESSMENTS

ZONE	2014 PASS RATE	2015 PASS RATE	2016 PASS RATE	2017 PASS RATE	2018 PASS RATE
1	97.8%	96.9%	98.4%	98.7%	97.0%
2	93.5%	96.6%	94.7%	97.1%	93.2%
3	93.7%	93.4%	91.3%	95.2%	94.9%

Overall, routine contamination measurements conducted throughout the facility in 2018 fell below the administrative limits 94.7% of the time, missing the internal target of ≥95% by a very small margin of 0.3%.

4.1.8 Discussion on the Effectiveness of Radiation Protection Program

Based upon the following factors and the overall evidence presented in this report, it is concluded that the SRBT radiation protection program has been effective throughout the year:

- Highest worker dose for 2018 of 0.48 mSv, or <1% of regulatory limit, and was for the fourth year in a row less than 1 mSv (representing the regulatory limit for a person who is not a nuclear energy worker).
- Collective dose and average dose remain stable relative to production levels.
- Contamination control data demonstrates a high level of control and an intolerance for contamination in excess of administrative limits.
- Although the target pass rate for contamination control was missed by 0.3%, a 94.7% pass rate for routine facility contamination checks is very good, and there were no personnel contamination events.
- Radiation protection equipment issues are minimal, with a continuing investment in new equipment leading to an excellent track record of maintenance and fitness for service.
- Radiation protection training results demonstrate that staff has a good appreciation and knowledge of how to protect themselves from hazards.

4.1.9 Occupational Dose Targets

As described in the 2017 annual compliance report, the occupational dose targets for 2018 were set as 0.75 mSv (maximum dose to staff member) and 0.060 mSv (average dose to all staff).

Both of these targets were achieved, as described above. The maximum dose to any worker was 0.48 mSv, while the average dose to all workers was 0.044 mSv.

SRBT projects that in 2019 both the maximum and average dose to workers should remain stable; however, as an additional improvement initiative, the Health Physics Team has lowered both targets going into the new year.

These targets are set as follows:

- Maximum dose: ≤ 0.70 mSv, and
- Average dose: ≤ 0.055 mSv

4.1.10 Summary of Radiation Protection Training and Effectiveness

All new staff members receive introductory training in radiation safety, even if they are not expected to handle nuclear substances as part of their responsibilities.

In 2018, four employees were hired and were provided with this initial indoctrination training that is required for declaration as a nuclear energy worker. Personnel performed well on the associated test, with no instances of remedial testing required.

On December 11, 2018, SRBT held its annual all-staff training session, which includes a comprehensive training presentation specifically regarding radiation protection concepts and requirements, specifically tailored to the type of hazard at SRBT.

Open dialogue was encouraged with a question and answer session, and a closed-book written test was provided to all participants.

A test is administered at the conclusion of the course; in 2018, all participants successfully challenged the test, with one exception. Test results averaged 96.4%, and any incorrect answer on the test was also discussed in detail with all employees individually to ensure full understanding in the days following the training.

A supplementary training session was held early in 2019 for the individual who did not pass the test during the original training session, as well as for three other individuals who were unable to attend the December 11 class for personal reasons. All four individuals succeeded in passing the training course.

4.1.11 Summary of Radiation Protection Equipment Performance

In 2018, all equipment associated with radiation protection at SRBT performed acceptably, and all key maintenance activities, such as instrument calibration, were performed as required.

Radiation protection equipment includes liquid scintillation counters, portable tritium in air monitors, stationary tritium in air monitors and portable radiation detectors (‘RadEye’ type alpha/beta/gamma detectors).

Two unscheduled corrective maintenance visits were conducted in 2018 by the manufacturer of the LSC units in order to resolve minor issues with rack jamming, and the chamber shutter mechanism.

4.1.12 Summary of Radiation Protection Improvements

In 2018, the following improvements were implemented with respect to the Radiation Safety Program at SRBT:

- The Radiation Safety Program was revised in February in response to regulatory feedback on Revision L of the program document.
- A new Dosimetry Service Program document was implemented as a subordinate component of the Radiation Safety Program, after being accepted as part of the renewal of our DSL on June 1, 2018.
- Procedure RSO-015, *Health Physics Team Training* was revised to incorporate improvements and align it with the latest practices in training.
- Procedure RSO-038, *PUTT Management* was revised to update responsibilities and improve the description of PUTT loading values.
- Various LSC-procedures were improved and modified to reflect best practices or operational learning.
- An additional spare stationary tritium-in-air monitor was procured for use by staff.
- All SAT-based training programs pertaining to health physics-related processes have been implemented after being designed and developed in the previous two years.

Overall, SRBT's Radiation Safety Program continues to provide an effective level of radiological protection to our workers, and continues to be improved over time.

4.2 SCA – Conventional Health and Safety

4.2.1 Jurisdiction

SRBT is subject to federal jurisdiction thus, the Canada Labour Code Part II (CLC Part II) and the Canada Occupational Health and Safety Regulations.

4.2.2 Conventional Health and Safety Program

Being under federal jurisdiction in 2018, the Health and Safety Program for the SRBT facility was compliant with the requirements of the CLC Part II & Canada Occupational Health and Safety Regulations.

4.2.3 Workplace Health and Safety Committee

In accordance with Section 135 (1) of the CLC Part II, SRBT maintains a Workplace Health and Safety Committee.

The Committee is comprised of four representatives. Under section 135(10) of the CLC Part II the Committee is required to meet no less than 9 times per year.

The Committee met 9 times in 2018, with all meeting minutes kept on file.

4.2.4 Minor Incidents

There were 15 minor incidents reported in 2018 where an employee required first aid treatment; of these, one of these resulted in medical care being sought at the local hospital as a precautionary measure.

A breakdown of the type of minor injuries occurring in 2018 is provided:

- Minor Cuts – 10
- Burns (flame) – 2
- Cut requiring stitches - 1
- Ankle injury – 1
- Strain injury – 1

All injuries requiring hospital care were reported to WSIB as required.

4.2.5 Lost Time Incidents

In 2018, no lost time incidents (LTI) occurred, compared to three such events in 2017.

The following table summarizes the frequency of occurrence of LTIs over the past five years:

TABLE 13: LOST TIME INCIDENTS (2014-2018)

DESCRIPTION	2014	2015	2016	2017	2018
LOST TIME INCIDENTS	0	0	0	3	0

SRBT's continuing goal is to have zero LTIs each year; the fact that this goal was achieved in 2018 speaks to the effectiveness of the actions taken in response to the three LTIs that occurred in 2017.

4.2.6 Health and Safety Goals

SRBT sets programmatic goals that are tracked by responsible safety committees throughout the year. Actions are taken that are intended to help the organization reach safety goals / objectives / targets, as well as when they may be missed.

In 2018, SRBT set the following goals for the area of Conventional Health and Safety:

- Zero lost time incidents (experienced zero – goal achieved)
- No more than twenty minor incidents (experienced 15 – goal achieved)

4.2.7 Reporting

In accordance with Section 15.10 (1) of Part XV of the Canada Occupational Health and Safety Regulations the Employer's Annual Hazardous Occurrence Report was submitted to Employment and Social Development Canada (ESDC) prior to March 1, 2018, as required.

In accordance with Section 9 of the Policy Committees, Work Place Committees and Health and Safety Representatives Regulations, the Work Place Committee Report was submitted to the Regional Safety Officer at Canada Labour prior to March 1, 2018, as required.

4.2.8 Health and Safety Training

The Manager - Safety and Security and an employee representative of the Health and Safety Committee attended a Health & Safety Training Conference in Ottawa on October 10, 2018, and took part in training seminars that included:

- A Day in the Life of a Supervisor in 2018
- Workplace Harassment and Violence – Bill C-65
- Update on the Laws of Drugs in the Workplace
- Removing the Mask – How to Respectfully Approach Employees Dealing with Mental Health Issues
- Eat, Sleep, Move – Eat Better, Move Better and Sleep Better

In December 2018, all SRBT staff were given refresher training in WHMIS at the annual SRBT training day.

4.2.9 Health and Safety Initiatives and Improvements

In 2018, several health and safety initiatives were implemented, and numerous improvements were put in place. Significant initiatives and improvements include:

- The Workplace Health and Safety Committee conducted all-staff safety meetings, focused on reinforcing the responsibilities and duties of both the employees and the employer when it comes to safety in the workplace.
- Health and safety procedures were improved and expanded.
- Sound level testing was completed for all facility processes, with protective measures put in place where advisable.
- New compressed air hose nozzles were installed which are designed to reduce sound levels during use.
- A sink used for washing light source preforms in the coating room was replaced with a safer design.
- A comprehensive, independent assessment of SRBT’s Health and Safety Program against the requirements of the *Canada Labour Code* and the *Canada Occupational Health and Safety Regulations* was completed. An implementation plan was put into place to address the key issues identified.

4.3 SCA – Environmental Protection

This section of the report will provide environmental protection compliance information, including results from environmental, effluent and groundwater monitoring, an assessment of compliance with any licence limits, historical trending where appropriate, and quality assurance/quality control results for the monitoring.

As part of SRBT's overall Environmental Protection Program, and as an input into the design of the environmental, effluent and groundwater monitoring programs, a conceptual site model (CSM) can provide a valuable representation of the factors and elements that are considered for monitoring within the boundaries of the program.

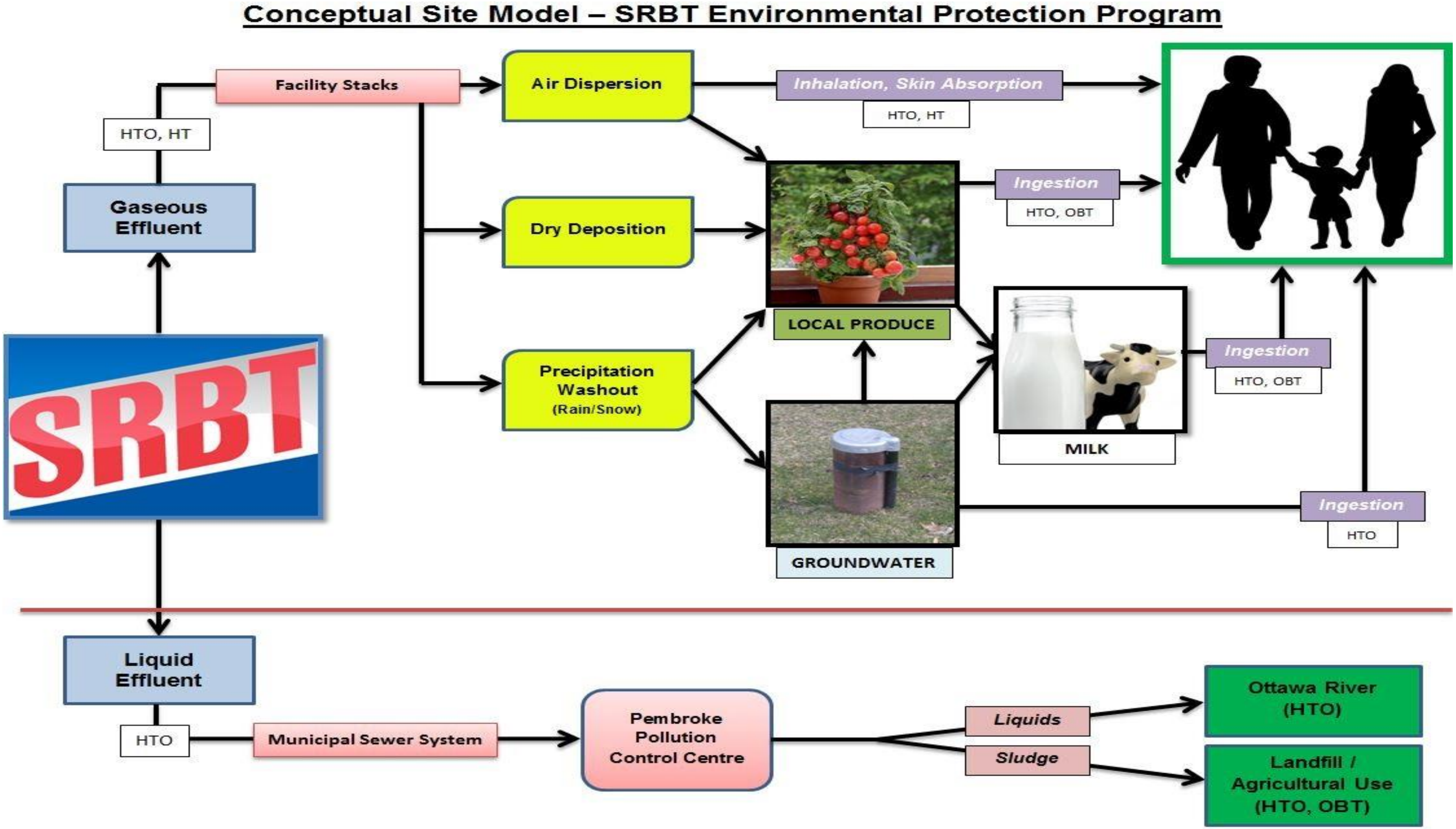
SRBT has been in operation since 1990, and has performed extensive monitoring of effluent, the environment and groundwater over the course of operations since then. In 2007, a comprehensive analysis was performed of the operations of the facility (including historical practices) in order to identify the sources of tritium that could affect the environment and the groundwater.

As well, in 2008 the significant environmental aspects of facility operation were initially established, and have been reviewed periodically since then in order to identify if there are other processes or operations that have been introduced that could lead to an impact on the environment.

These analyses, coupled with decades of operational experience, leads to the establishment of a simplified CSM that shows the significant pathways and environmental interactions pertaining to the release of the sole radiological contaminant of potential concern – tritium.

A simplified pictographic representation of these source – receptor pathways is provided below, and should be consulted when considering the information provided in the next three subsections of this report.

FIGURE 7: CONCEPTUAL SITE MODEL



As part of ensuring compliance with the reporting requirements of several N288-series of standards, SRBT has committed to ensuring that the information required by each applicable in-force standard to be reported annually pertaining to the environmental monitoring, effluent monitoring and groundwater monitoring programs is included our annual compliance report.

A summary of the requirements of each of the applicable standards is provided here.

N288.4-10: Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills: Section 11.2.2 – “The report shall include”:

TABLE 14: REPORTING REQUIREMENTS (N288.4-10)

	REQUIREMENT	REPORT SECTION
a	The results of the EMP, including measurements of the monitored hazardous and/or nuclear substances, physical stressors, and physical and biological parameters, including their statistical analyses (i.e. assessment of changes through space and time).	4.3.1 **Appendices F through N**
	Radiation doses calculated as doses to receptors where this is required.	4.3.5 **Appendix S**
	An assessment of the EMP results compared with the previous performance indicator targets.	4.3 Reference is made to previous years for performance indication.
	Documentation and justification of any deviations from field sampling, and analytical and data management procedures.	4.3.1.10 4.3.1.11
b	A summary and assessment of the field and laboratory QA/QC results including any non-conformances.	4.3.1.12
c	A summary of the audit and review results and subsequent corrective actions.	4.3.7
d	A summary of any proposed modifications to the EMP.	4.3.8
e	Documentation, assessment and review of any supplementary studies that have been initiated, completed, or both.	4.3.1.13

N288.5-11: Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills: Section 11.2.2 – “The report shall include the results of the effluent monitoring program, including at least”:

TABLE 15: REPORTING REQUIREMENTS (N288.5-11)

	REQUIREMENT	REPORT SECTION
a	The amount or concentration of radioactive nuclear substances and hazardous substances released, as required to demonstrate compliance with regulatory limits and performance with respect to any other release target (e.g., action levels).	4.3.2 Action levels and other targets: 4.3.2.2, 4.3.2.4 and 4.3.2.5 **Appendices O and P**
b	The characteristics of the effluents.	4.3.2
c	The results of any toxicity testing conducted (if required).	Not applicable
d	A summary and assessment of the field and laboratory QA/QC results, including any non-conformance.	4.3.2.6
e	A statement of uncertainties inherent in the monitoring results and any dose estimates derived from them.	4.3.2.7 Dose estimates are derived using EMP data
f	A summary of the audit and review results and subsequent corrective actions.	4.3.7
g	A summary of any proposed modifications to the effluent monitoring program.	4.3.8
h	Documentation, assessment, and review of any supplementary studies that have been initiated or completed, or both.	4.3.2.8

N288.7-15: Groundwater protection programs at Class I nuclear facilities and uranium mines and mills: Section 11.1 – “A facility should prepare annual monitoring reports documenting the GWMP, which include the following”:

TABLE 16: REPORTING REQUIREMENTS (N288.7-15)

	REQUIREMENT	REPORT SECTION
a	The results of the GWMP including i) completeness of monitoring activities (identify if all planned activities were accomplished); ii) measurements of the monitored substances, biological, and hydrogeological parameters based on program objectives; and iii) data analysis and interpretations.	4.3.3 **Appendix O**
b	Relevant groundwater and hydrogeological characteristics.	4.3.3 **Appendix R**
c	Doses calculated for the identified receptors (if doses have been calculated to aid in interpreting GWMP results).	Not applicable: GMP data does not contribute to dose calculations (residential wells fall within scope of EMP)
d	A summary and assessment of the field and laboratory QA results, including any non-conformances.	4.3.3.3
e	A statement of uncertainties inherent in the monitoring results and any dose estimates derived from them (where applicable).	4.3.3.4 4.3.5
f	Documentation of any supplementary studies that have been initiated, completed, or both (with references to the original studies).	4.3.3.5
g	An overall statement of data quality and discussion of results in terms of data performance and acceptance criteria.	4.3.3.6
h	Discussion of monitoring results in terms of program objectives and the conceptual site model.	4.3.3.7
Note 1	A summary of any audits performed, their results, and any corrective actions taken as a result of the audit’s findings may also be included in the reporting.	4.3.7

4.3.1 Environmental Monitoring

SRB Technologies (Canada) Inc. implements a comprehensive Environmental Monitoring Program (EMP)[40] that provides data for site-specific determination of tritium concentrations along the various pathways of exposure to the public due to the activities of the operations.

4.3.1.1 Passive Air Monitoring

A total of 40 passive air samplers (PAS) are located throughout a two kilometer radius from the SRBT facility, in eight sectors, ranging in distance at 250, 500, 1,000, and 2,000 meters.

The samples were collected on a monthly basis by a for tritium concentration assessment by the third party laboratory, with a minimum detectable activity (MDA) ranging between 0.28 - 0.35 Bq/m^3.

Several duplicate samplers are included for quality assurance purposes. Several samplers are also located specifically to provide data for assessment of the defined critical group members. PAS results for 2018 can be found in the table in **Appendix F** of this report.

The table shows the tritium oxide (HTO) concentrations for the samplers located in each of the eight compass sectors. Tritium oxide in air concentrations for each month of 2018 are graphically represented for each of eight compass sectors and for each of the distances from the facility and are found in **Appendix G** of this report.

The PAS array represents the tritium exposure pathways for inhalation and skin absorption; results are used in the calculations for critical group annual estimated dose for 2018.

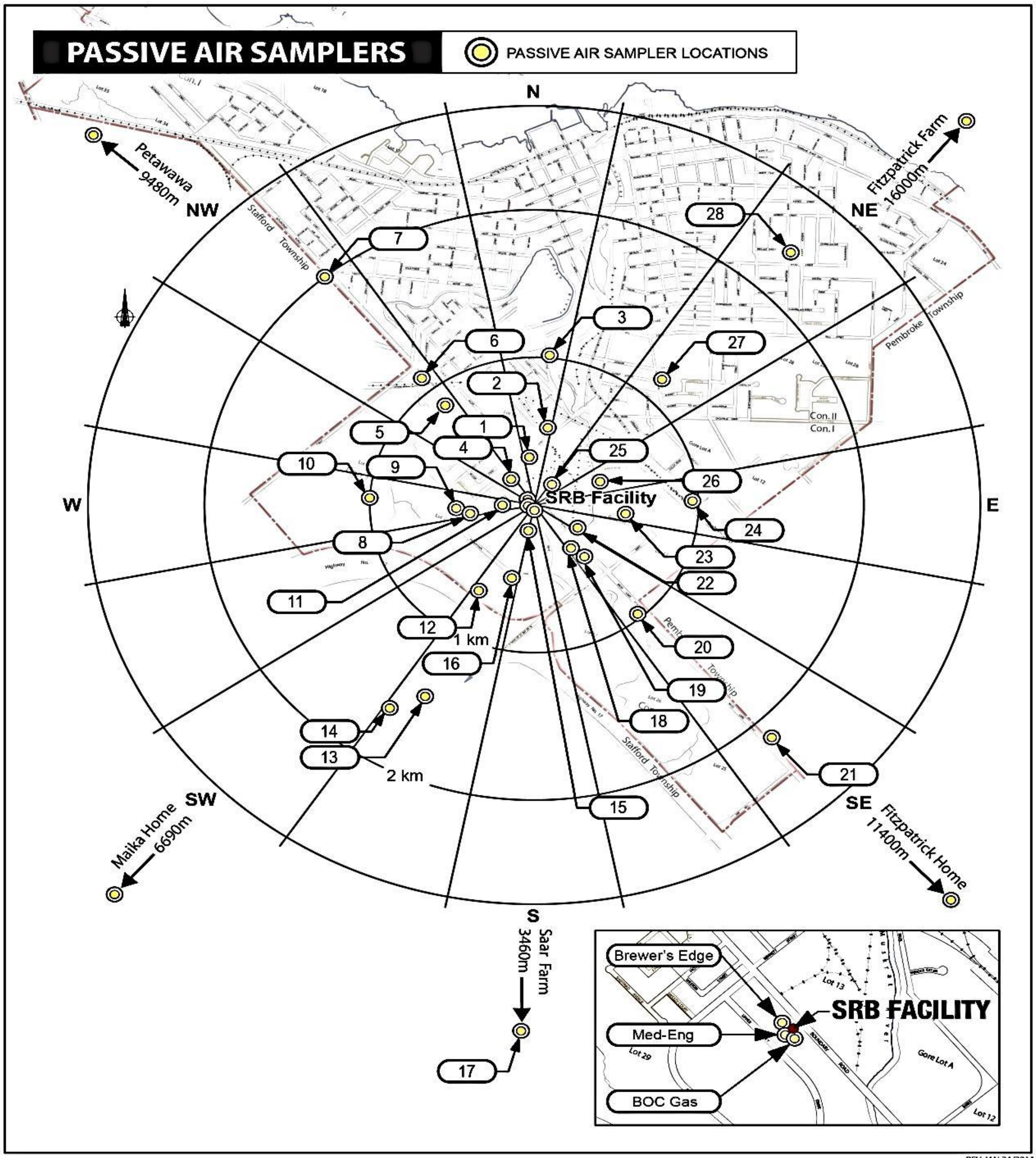
The sum of the average concentration for the passive air samplers in 2018 was 44.43 Bq/m^3,a value that is slightly elevated when compared with the value observed in 2017 (38.85 Bq/m^3).

Total tritium emissions in 2018 were 33,180 GBq, an increase of approximately 34% of the emissions in 2017 (24,822 GBq). The oxide component of tritium emissions increased as well in 2018 (10,741 GBq) versus 2017 (7,198 GBq).

The data relating to PAS in 2018 continues to demonstrate that the environmental monitoring program collects data that consistently reflects the emissions from the facility.

The relative positioning of the PAS array used as part of the EMP is provided here:

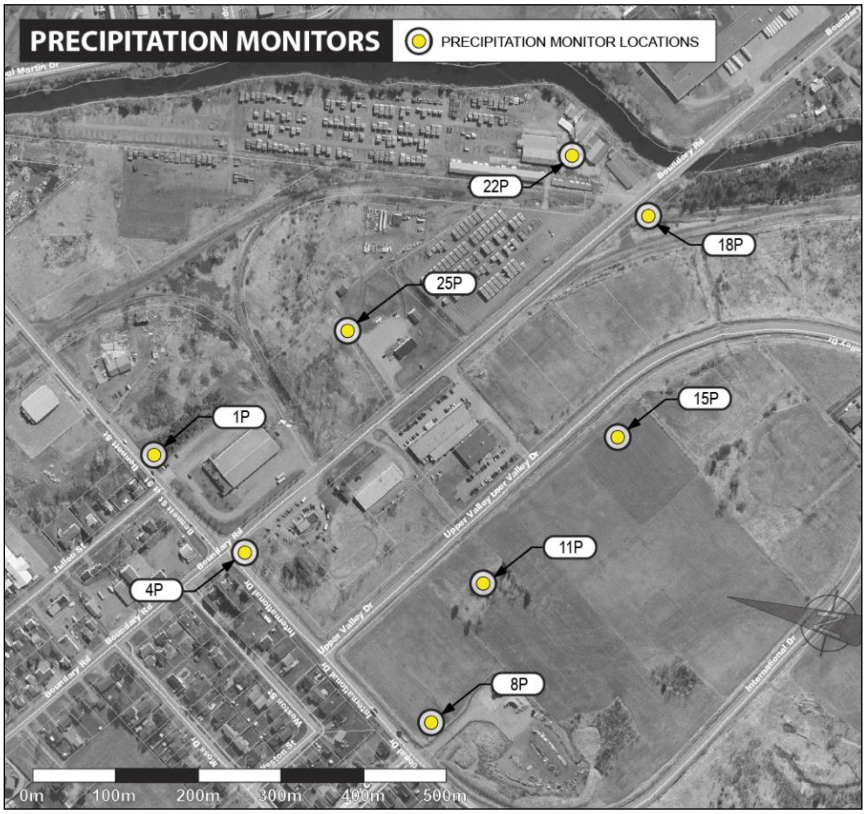
FIGURE 8: LOCATION OF PASSIVE AIR SAMPLERS



4.3.1.2 Precipitation Monitoring

Eight precipitation monitors are installed near existing air monitoring stations that are located approximately 250 m from the facility.

FIGURE 9: LOCATION OF PRECIPITATION MONITORS



The samples were collected on a monthly basis by a third party laboratory for tritium concentration assessment. Averaged results in 2018 ranged between 16 Bq/L (sampler 1P) and 80 Bq/L (sampler 18P), with a MDA of between 5 - 6 Bq/L.

The average tritium concentration for all eight precipitation monitors in 2018 was 34 Bq/L, a slight decrease when compared to the 2017 average of 42 Bq/L.

This represents a very slight decrease that cannot be attributed to a single cause, as the geographic distribution of the sample collectors, coupled with any given meteorological conditions during processing, is expected to yield some variations in the data year-to-year.

Precipitation monitoring results for 2018 and comparisons can be found in **Appendix H** of this report.

4.3.1.3 Receiving Waters Monitoring

Samples of receiving waters downstream from SRBT in the Muskrat River were collected and analyzed monthly by a third party laboratory.

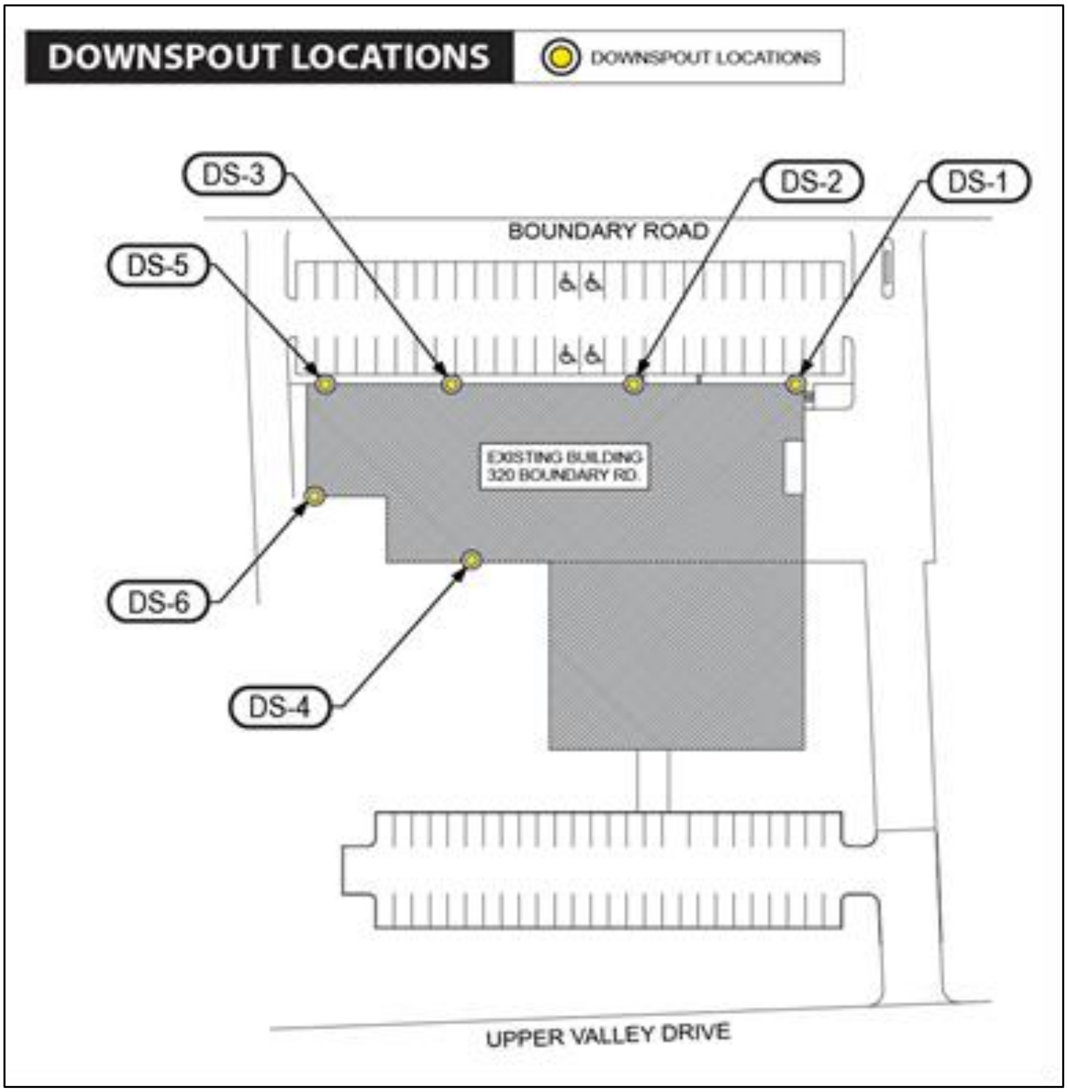
All obtained samples of receiving waters in 2018 fell below the MDA for tritium concentration (between 5 - 6 Bq/L), as they were in 2017.

Receiving waters monitoring results are trended in **Appendix I** of this report

4.3.1.4 Downspout Runoff Monitoring

Tritium concentrations are measured in all facility downspouts (DS). The samples were collected periodically by SRBT for tritium concentration assessment.

FIGURE 10: LOCATION OF FACILITY DOWNSPOUTS



Runoff from downspouts was collected during four precipitation events throughout 2018, with a total of 21 samples being assessed.

The average tritium concentration for all downspouts / facility runoff in 2018 was 179 Bq/L; in 2017, this value was 172 Bq/L. The highest value measured was from DS-2 on February 21 (493 Bq/L), while the lowest value measured was 48 Bq/L on October 31 (both DS-3 and DS-6).

Runoff monitoring results can be found in **Appendix J** of this report.

Please note that the downspout collection point for DS-1, on the roof of the southeast corner of the building in which the SRBT facility is housed, is of a higher elevation that the other five points. As such, water does not typically flow down through DS-1 during most periods of rain as it does not reach the drain on the roof, unless the rate of precipitation is significant.

4.3.1.5 Produce Monitoring

Produce from a local produce stand and from five local residential gardens were sampled in 2018.

The samples were collected and assessed by a third party laboratory to establish free-water tritium concentration, as well as an assessment of organically-bound tritium (OBT) in specific samples (produce sample minimum detectable activity = approximately 3 Bq/kg).

The official results were compiled and reported to the participating members of the public, and are also posted on our website. This data is used in the calculations for annual estimated dose to the public for 2018.

The average free water tritium concentration in produce offered by local residents in 2018 was 97 Bq/kg, a value that is higher than the 2017 figure of 46 Bq/kg.

The average free water tritium concentration in produce offered by the local farm gate was 4 Bq/kg, a measurement that is comparable with the 2017 value of 8 Bq/kg.

For OBT, samples of tomatoes from a nearby residential garden showed a concentration of 4 Bq/kg, while tomatoes from the commercial garden were measured at 3 Bq/kg.

Produce monitoring results and locations for calendar year 2018 can be found in **Appendix K** of this report, along with graphs comparing historical results of the program.

4.3.1.6 Milk Monitoring

Milk from a local producer and from a local distributor is sampled every four months. The samples were collected and analyzed for tritium concentration by a third party laboratory. This data is also used in the calculations for critical group annual estimated dose for 2018.

Milk monitoring results and locations for 2018 can be found in **Appendix L** of this report.

Tritium concentrations in milk remained very low, with 100% of the samples being assayed as less than the MDA of 3 - 4 Bq/L, compared to 2017 where four out of the six milk samples were less than the MDA, while no sample exceeded 5 Bq/L.

4.3.1.7 Wine Monitoring

Wine from a local producer is sampled once a year. The samples were collected and analyzed for tritium concentration by a third party laboratory (MDA = approximately 3.6 Bq/L).

Wine monitoring results for 2018 remain low at 15 Bq/L, a slight increase compared to 2017 (11 Bq/L).

Annual data can be found in **Appendix M** of this report with a graph trending results from 2006 to 2018.

4.3.1.8 Weather Data

A weather station near the facility collects data on a continuous basis. See weather data for 2018 in **Appendix N**.

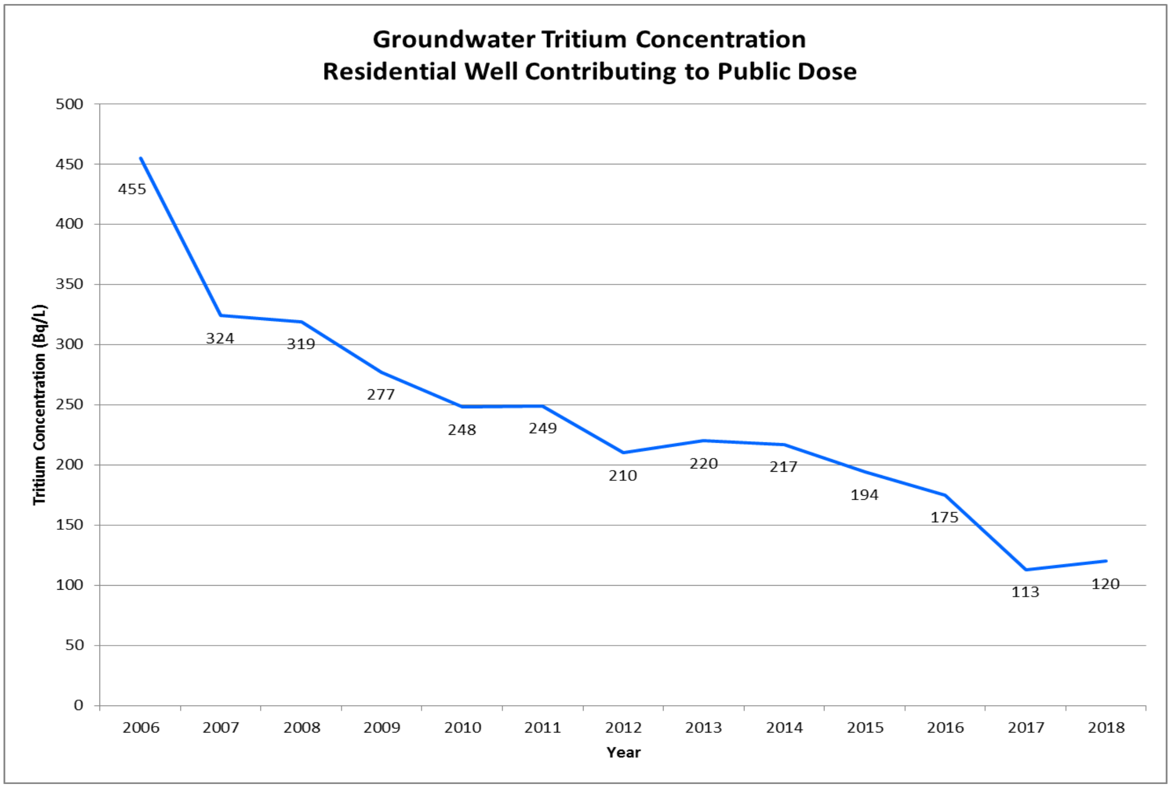
4.3.1.9 Residential Drinking Water

Several nearby local residences permit SRBT to acquire samples of drinking water three times annually, to provide additional data for our program.

An independent third party collects and analyzes residential drinking water samples (MDA = approximately 3 – 4 Bq/L).

In 2018, the highest residential well tritium concentration value was measured in RW-8 (now disconnected) at 120 Bq/L, a value that is well below the Ontario Drinking Water Quality Standard of 7,000 Bq/L. In 2017, the highest measured value was 113 Bq/L from the same well.

FIGURE 11: RESIDENTIAL WELL TRITIUM CONCENTRATION TREND (2006-2018)



Four wells traditionally sampled as part of our EMP (including RW-8) have now been shut down after the homes have been connected to the municipal water supply in the last two years.

Derived public dose values attributed to residential well water consumption have decreased since the inception of the monitoring program as a direct result of our efforts to minimize our environmental impact.

Residential well monitoring results for 2018 can be found in **Appendix O** of this report.

4.3.1.10 Deviations from Field Sampling Procedures

In 2018, there were no noted occurrences of deviations from field sampling procedures.

4.3.1.11 Deviations from Analytical and Data Management Procedures

In 2018, there were no noted occurrences of deviations from analytical and data management procedures.

4.3.1.12 Field and Laboratory QA/QC Results and Non-conformances

Field and laboratory operations conducted by the independent third party laboratory include several quality assurance and quality control activities.

Field QA/QC activities include duplicate sampling of five passive air sampler stations, duplicate sampling of the Muskrat River, and the use of trip / method blanks for samples obtained in the field.

Laboratory QA/QC activities include tritium spiking of certain collected samples and blanks, as well as laboratory reference standards for low and high activity concentrations. Sample QC is tested using spike recovery and relative percent difference (RPD) tests.

In 2018, there was one non-conformance raised pertaining to quality control results generated by an independent third-party laboratory (Canadian Nuclear Laboratories).

A technical review of reporting spreadsheets for certain EMP sample types uncovered a discrepancy in the way the expected value for quality control standards was calculated.

Investigation revealed that a component of the calculation which should factor in decay of the standards was inadvertently deleted from the spreadsheet by CNL at some point.

Upon discovering the issue, the program manager raised a non-conformance report, and contacted CNL technical specialists to confirm the issue. The spreadsheets were corrected in order to take into account decay going forth.

The program manager also back-calculated the decay factors into the last several months of data and confirmed that each set of EMP data still met data acceptance criteria of +/-20% relative percent difference between the expected value and the measured value of each quality control standard.

SRBT executes an internal data acceptance process as per procedure EMP-013, *Acceptance Criteria for EMP.* This serves to further confirm the quality and acceptability of the data generated by the EMP.

In 2018, there were 226 QC checks and 649 benchmark value comparisons performed on EMP data, with 99.6% of all EMP QC checks meeting acceptance criteria, while 100% of all EMP measurements were below benchmark values.

There was one instance where a QC acceptance criterion was not met. For the July sample data, the ‘NE250’ and ‘NE250’ duplicate samples exhibited a relative percent difference of 51% (6.60 and 11.10 Bq/m3), in excess of the acceptance criteria of 40%. The higher value was used as the data point for the July set.

A non-conformance report was raised, and the contractor was actioned to clean the PAS orifice from both samplers using portable compressed air, as a partially blocked orifice may have artificially obstructed the flow of air into the sampler that exhibited the lower concentration. Construction had been performed nearby that may have increased the dust loading in the air near the sampler.

The data for these two samplers has since continually met the acceptance criterion for each sampling period.

4.3.1.13 Supplementary Studies – 2018

There were no supplementary studies initiated or completed relating to the SRBT EMP in 2018.

4.3.2 Effluent Monitoring

SRBT monitors two main effluent streams from the facility for tritium.

Tritium releases via the gaseous effluent pathway (active ventilation) are monitored in real time, with integrated measurements being conducted weekly to determine total emissions and verify compliance with licence limits and action levels.

Liquid effluent is retained in batches and analyzed for tritium concentration prior to being released to sewer.

4.3.2.1 Gaseous Effluent

In 2018, SRBT operated well within release limits to atmosphere that are prescribed as part of the operating licence of the facility. The operating licence (NSPFOL-13.00/2022)[1] references release limits defined in Appendix E of the Licence Conditions Handbook[2].

A summary of the releases of tritium oxide and total tritium in 2018 is tabulated below:

TABLE 17: GASEOUS EFFLUENT DATA (2018)

NUCLEAR SUBSTANCE AND FORM	ANNUAL LIMIT (GBq)	2018 RELEASED (GBq)	% LIMIT	WEEKLY AVERAGE (GBq)	MAXIMUM WEEKLY RELEASE (GBq)
TRITIUM AS TRITIUM OXIDE (HTO)	67,200	10,741	15.98%	207	507
TOTAL TRITIUM AS TRITIUM OXIDE (HTO) AND TRITIUM GAS (HT)	448,000	33,180	7.41%	638	2,431

Please refer to **Appendix P** for a complete data set on tritium releases to atmosphere in 2018.

For comparison, in 2017 HTO emissions were 10.71% of the licence limit, while total tritium emissions were 5.54% of the licence limit.

Total air emissions in 2018 increased by approximately 34% of what they were in 2017, while annual tritium processed decreased by about 5%. Several factors have influenced these figures this year; most significantly, a high rate of production took place during the summer months when meteorological conditions can often lead to increased levels of tritium releases.

Details on the past five years of gaseous effluent data are provided below for ease of trend analysis:

TABLE 18: GASEOUS EFFLUENT DATA (2014-2018)

NUCLEAR SUBSTANCE AND FORM	RELEASED 2014 (GBq)	RELEASED 2015 (GBq)	RELEASED 2016 (GBq)	RELEASED 2017 (GBq)	RELEASED 2018 (GBq)
TRITIUM AS TRITIUM OXIDE (HTO)	10,712	11,554	6,293	7,198	10,741
TOTAL TRITIUM AS TRITIUM OXIDE (HTO) AND TRITIUM GAS (HT)	66,161	56,237	28,945	24,822	33,180

When analyzing the operation's performance at reducing emissions it is important to assess the releases to atmosphere against the amount of tritium the facility processed. This provides an indication at how effective emission reduction initiatives have been successful in reducing emissions.

The following table defines the ratio of tritium released to atmosphere against tritium processed since 2008:

TABLE 19: TRITIUM RELEASED TO ATMOSPHERE vs PROCESSED (2008-2018)

YEAR	TRITIUM RELEASED TO ATMOSPHERE (GBq/YEAR)	TRITIUM PROCESSED (GBq/YEAR)	% RELEASED TO PROCESSED	% INCREASE (+) REDUCTION (-)
2008	40,100	2,356,979	1.70	N/A
2009	40,547	5,045,720	0.80	- 53%
2010	36,426	6,643,732	0.55	- 31%
2011	55,584	7,342,449	0.76	+ 38%
2012	29,905	10,224,590	0.29	- 62%
2013	78,875	30,544,759	0.26	- 10%
2014	66,161	28,714,119	0.23	-12%
2015	56,237	27,989,832	0.20	-13%
2016	28,945	28,122,678	0.10	-50%
2017	24,822	32,968,695	0.08	-20%
2018	33,180	31,251,329	0.11	+38%

In 2018, the ratio of tritium released versus processed rose for the first time since 2011. Again, several factors contributed to this phenomenon as previously discussed; however, it is important to note that despite the relative increase in this metric, we were still able to achieve our internal target of 0.13% for the year.

4.3.2.2 Air Emission Target

SRBT set an annualized total tritium emission target at the beginning of 2018 of ≤ 650 GBq / week (averaged over the year), and was successful in meeting this target (638 GBq / week). During the course of the calendar year, the weekly target value was exceeded twenty times, most of which came between June – September (17 instances) when production rates were increased substantially, and meteorological conditions typically lead to higher gaseous tritium emissions.

For calendar year 2019, SRBT has retained a tritium emission target of 650 GBq / week or less, on average, based upon projected production rates and the value achieved in 2018.

The 2018 targeted tritium released to processed ratio of ≤ 0.13% was achieved (0.11%). The 2019 target has been also been retained at 0.13%.

4.3.2.3 Liquid Effluent

In 2018, SRBT operated well within release limits to sewer that are prescribed as part of the operating licence of the facility, as defined in Appendix E of the Licence Conditions Handbook[2].

TABLE 20: LIQUID EFFLUENT DATA (2018)

NUCLEAR SUBSTANCE AND FORM	LIMIT (GBq/YEAR)	RELEASED (GBq/YEAR)	% OF LIMIT
TRITIUM – WATER SOLUBLE	200	10.02	5.01%

Total liquid effluent releases in 2018 increased when compared to 2017 values (10.02 GBq in 2018 vs. 6.85 GBq in 2017).

The increase is attributed mainly to a continued increase in the manufacture of miniature light sources, a type of light source which, when assayed for integrity via water-submersion testing, can typically introduce elevated concentrations of tritium in collected effluent.

Details on the past five years of liquid effluent data are provided below for ease of trend analysis:

TABLE 21: LIQUID EFFLUENT DATA (2014-2018)

NUCLEAR SUBSTANCE AND FORM	RELEASED 2014 (GBq)	RELEASED 2015 (GBq)	RELEASED 2016 (GBq)	RELEASED 2017 (GBq)	RELEASED 2018 (GBq)
TRITIUM – WATER SOLUBLE	12.5	6.5	5.18	6.85	10.02

Please refer to **Appendix Q** for a complete data set of liquid effluent releases to sewer in calendar year 2018.

4.3.2.4 Liquid Effluent Target

SRBT set a total tritium release target at the beginning of 2018 of ≤ 7 GBq for the year, a target that was missed by 3.02 GBq.

Based upon continuing production of miniature light source into the 2019 calendar year, and based upon the past two years of data, SRBT has set the total liquid effluent release target at 9 GBq for 2019.

4.3.2.5 Action Level Exceedances

In 2018, there were no instances of an action level exceedance related to gaseous or liquid effluent monitoring at SRBT.

4.3.2.6 Summary of Field and Laboratory QA/QC

Effluent monitoring activities include several procedural steps that ensure acceptable quality assurance and control, including duplicate / triplicate sample acquisition and measurement, the use of process blanks, and the measurement of known reference standards as part of the assay of activity in collected sample media.

All QA/QC results obtained in 2018 were acceptable with no identified non-conformances.

4.3.2.7 Statement of Uncertainties Inherent in Monitoring Results

Uncertainties associated with effluent monitoring at SRBT may be present at several points in the process.

For gaseous effluent, such uncertainties include: sampling representativeness, total airflow collected, catalytic efficiency of HT to HTO conversion, capture efficiency of sample media, standard measurement errors associated with liquid scintillation counting, sample acquisition errors such as volume of drawn sample for analysis, and errors in stack flow rate and differential pressure measurement.

For liquid effluent, such uncertainties include: sample volume, liquid effluent volume, standard measurement errors associated with liquid scintillation counting, and sample acquisition errors such as volume of drawn sample for analysis.

In order to ensure that the uncertainties inherent in monitoring results are kept acceptably low, SRBT ensures that a third party laboratory conducts independent verification procedures on the gaseous effluent monitoring system on an annual basis. Allowable deviation between the assessed measurement of gaseous emissions is +/- 30%; in 2018, results were within this acceptance criteria.

The QA/QC processes associated with gaseous effluent monitoring contribute to the confidence in the results. This includes independent verification of the assessment of gaseous releases at several levels. As well, the data gathered from the EMP is assessed against the data from the gaseous effluent monitoring process on a frequent basis to verify that results are relatively consistent with each other.

For liquid effluent, uncertainties inherent in monitoring results are addressed by QA/QC processes associated with liquid effluent monitoring, as well as independent verification of the assessment of releases.

The inherent uncertainties associated with effluent monitoring are well within acceptable bounds when contrasted against the measured releases, and the licenced limits for releases by each pathway.

4.3.2.8 Supplementary Studies

In 2018, no supplementary studies were conducted relating to effluent monitoring at SRBT.

4.3.2.9 Hazardous Substance Releases

In 2018 SRBT continued to operate the facility under a Certificate of Approval (Air), number 5310-4NJQE2[41], issued by the Ontario Ministry of the Environment in accordance with section 9 of the Ontario Environmental Protection Act.

No hazardous non-radiological substances are released from the facility through either gaseous or liquid effluent pathways in any significant quantity.

4.3.3 Groundwater Monitoring

SRBT implements and maintains a comprehensive Groundwater Monitoring Program (GMP) as part of our Groundwater Protection Program.

Groundwater data is reported to CNSC staff on a monthly basis, within 30 days of sampling, as required by Licence Conditions Handbook section 4.2, clause 2.

Dedicated, engineered sampling wells are used to establish tritium concentrations in the groundwater each month at various depths and in differing geologic strata. Variations are trended over time to measure the response of historical contamination of the local aquifer.

Since the program was established, groundwater measurements have been in very good agreement with established hydrogeological modelling predictions.

While most of the released tritium in the air is dispersed, some of it will reach the soil through dry and wet deposition. Infiltrated precipitation brings tritium into the groundwater below it. The deposition of tritium on and around the facility from air emissions and resulting soil moisture and standing water are the sole direct contributor to tritium found in groundwater.

Groundwater is affected by the percolation of soil moisture and standing water from the surface. Current concentrations in the wells are expected to gradually decrease once all historical emissions have flushed through the system and/or decayed with some influence of higher concentrations in nearby wells from lateral underground water flow.

This continues to be confirmed by routine monitoring of the existing network of wells. The rate at which this decrease will occur is dependent on the level and speed of recharge of the groundwater on and around the SRBT facility.

In 2018, 354 samples of groundwater were successfully obtained and analyzed, with all planned groundwater monitoring activities being accomplished, except for the following nine instances:

- MW06-3 was found to be dry four times between August through November.
- CN-1S could not be sampled during the July and November sample campaigns as it was dry.
- CN-1D, -3S and -3D were also found to be dry during the November sample campaign.

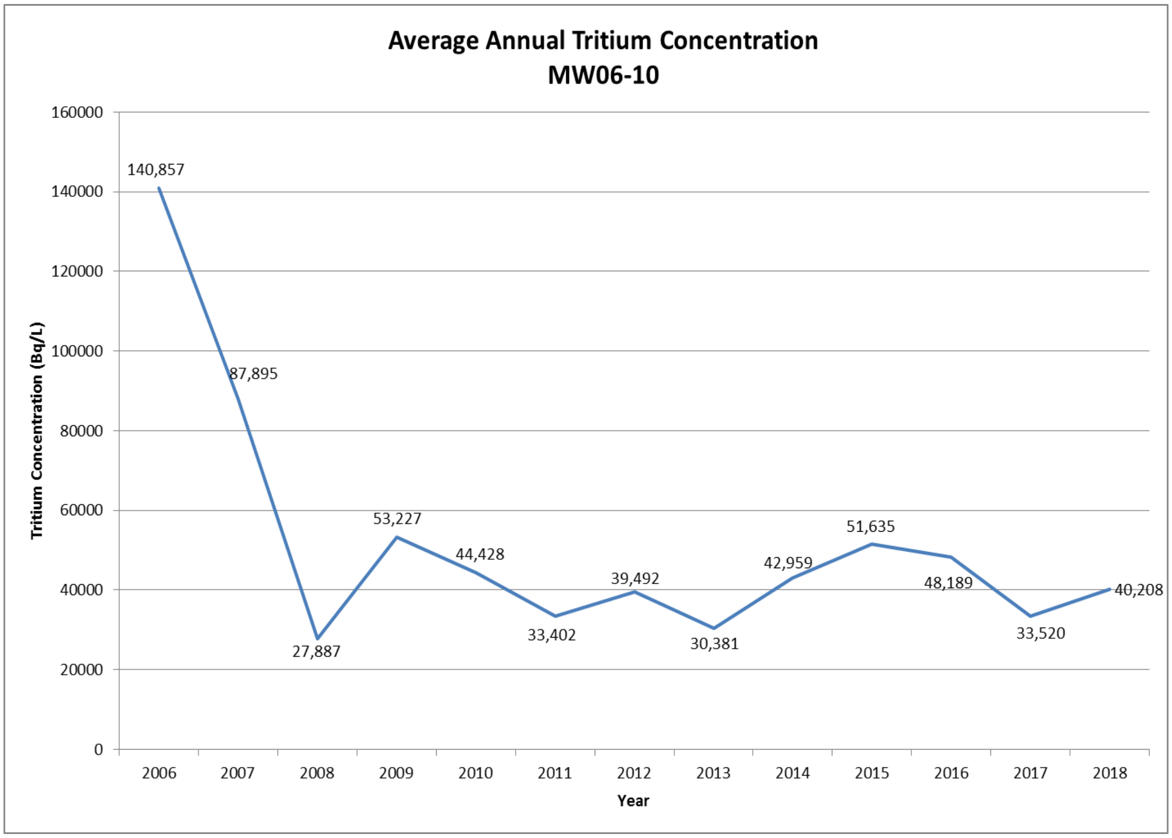
4.3.3.1 Groundwater Tritium Concentration

Groundwater monitoring well results for 2018 can be found in **Appendix O** of this report.

The highest average tritium concentration in any well remains in monitoring well MW06-10 which is directly beneath the area where the active ventilation stacks are located. As of the end of 2018, this represents the only well where tritium concentration exceeds the Ontario Drinking Water Guideline value of 7,000 Bq/L.

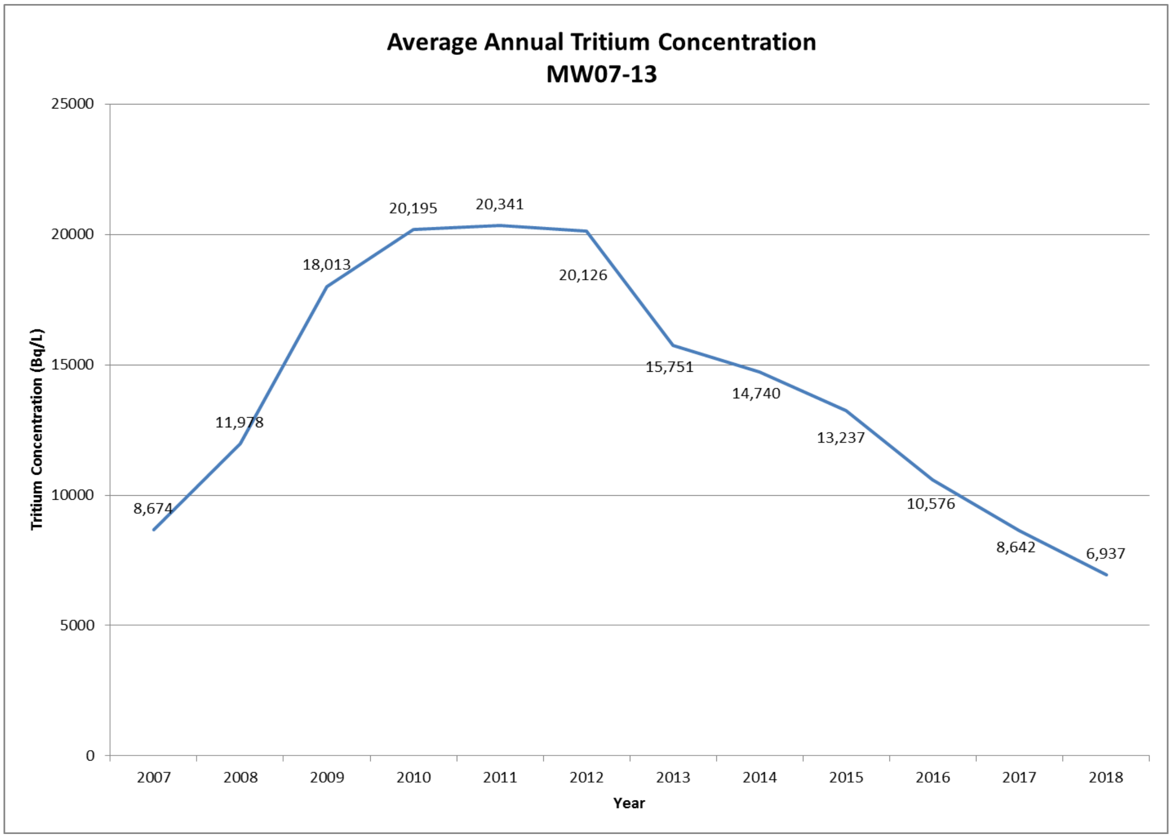
The average concentration of tritium measured in MW06-10 increased by approximately 20%, from 33,520 Bq/L in 2017 to 40,208 Bq/L in 2018. The average concentration remains lower than the 2016 value of 48,189 the 2015 value of 51,635 Bq/L, and the 2014 value of 42,959 Bq/L.

FIGURE 12: MW06-10 TRITIUM CONCENTRATION TREND (2006-2018)



The average concentration of MW07-13 in 2018 was measured at 6,937 Bq/L, marking the first time it has fallen below the drinking water standard concentration of 7,000 Bq/L since it was commissioned. In 2017 this well averaged 8,642 Bq/L, with the 2016 value of 10,576 Bq/L and the 2015 value of 13,237 Bq/L.

FIGURE 13: MW07-13 TRITIUM CONCENTRATION TREND (2007-2018)



In 2018, 24 of 29 SRBT-installed groundwater monitoring wells exhibited an average tritium concentration that was lower than the previous year.

The following table compares the annualized average tritium concentration of the 29 dedicated, SRBT-installed groundwater monitoring wells between 2015 through 2018.

Comparisons are made in the three columns on the right hand side of the table using a three-colour gradient, where green indicates decreasing concentrations, white indicating stable, and orange indicating a relative increase.

TABLE 22: 2015-18 AVERAGE TRITIUM CONCENTRATION IN ACTIVE MW

Well ID	2018	2017	2016	2015	2018 / 2017	2018 / 2016	2018 / 2015
	(Bq/L)				(%)	(%)	(%)
MW06-1	1334	1,946	2,753	4,338	68.5	48.5	30.8
MW06-2	1160	1,166	1,467	1,965	99.5	79.1	59.0
MW06-3	469	683	1,029	1,218	68.6	45.5	38.5
MW06-8	724	780	848	906	92.8	85.4	79.9
MW06-9	1952	2,224	2,476	2,731	87.8	78.8	71.5
MW06-10	40208	33,520	48,189	51,635	120.0	83.4	77.9
MW07-11	1122	1,099	1,344	1,521	102.1	83.5	73.8
MW07-12	468	467	469	463	100.1	99.7	100.9
MW07-13	6937	8,642	10,576	13,237	80.3	65.6	52.4
MW07-15	1505	1,617	1,810	1,680	93.1	83.1	89.6
MW07-16	1433	1,649	1,879	2,188	86.9	76.2	65.5
MW07-17	359	335	602	780	107.2	59.6	46.0
MW07-18	2192	2,739	3,690	5,491	80.1	59.4	39.9
MW07-19	1889	1,926	2,500	3,222	98.1	75.6	58.6
MW07-20	498	571	670	775	87.2	74.3	64.2
MW07-21	778	879	1,009	1,121	88.5	77.1	69.4
MW07-22	974	1,023	1,131	1,171	95.2	86.1	83.2
MW07-23	1572	1,743	1,929	2,206	90.2	81.5	71.2
MW07-24	1928	2,022	2,206	2,314	95.4	87.4	83.3
MW07-26	904	1,190	1,491	1,941	76.0	60.6	46.6
MW07-27	3136	3,589	4,292	4,869	87.4	73.1	64.4
MW07-28	1017	1,063	1,311	1,446	95.7	77.6	70.3
MW07-29	2415	2,472	3,395	3,950	97.7	71.1	61.1
MW07-31	407	186	440	756	219.1	92.6	53.9
MW07-32	70	76	155	128	91.5	44.9	54.4
MW07-34	1889	2,291	2,822	3,312	82.5	66.9	57.0
MW07-35	2637	3,015	3,448	3,945	87.5	76.5	66.9
MW07-36	2008	2,109	2,618	2,892	95.2	76.7	69.4
MW07-37	830	871	989	1,009	95.2	84.0	82.2

Several factors can influence the concentration of tritium in any given well, including the rate of precipitation accumulation, contaminant dispersion patterns, and the lateral and vertical migration of historical contaminant plumes.

4.3.3.2 Groundwater Level Measurements

The water levels are measured in monitoring wells on a monthly basis prior to purge and sampling. Analysis of this data shows consistent trends from year to year when comparing season to season.

A compilation of groundwater level measurements for 2018 can be found in **Appendix R** of this report.

4.3.3.3 Summary of Field and Laboratory QA/QC

In 2017, beginning in September SRBT commenced performing all groundwater monitoring activities with the implementation of the Groundwater Protection and Monitoring Programs, after consultation with CNSC staff and after conducting laboratory intercomparison work with the independent third party in the first quarter of the year.

These programs were submitted to CNSC staff and accepted as meeting the requirements of CSA standard N288.7-15, *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills.*

Field and laboratory operations pertaining to groundwater monitoring conducted by both the independent third party laboratory (January – August) and SRBT (September – December) include several quality assurance and quality control activities.

Quality control activities include duplicate sampling of certain wells, duplicate laboratory subsampling, and the use of trip / method blanks during sampling campaigns. As well, several quality control checks are performed as part of the liquid scintillation counting procedures employed by both the third party and SRBT.

In 2018, one non-conformance was raised relating to groundwater monitoring laboratory quality control, where background values measured during liquid scintillation counting were found to occasionally exceed trip blank values. It is expected that these measurements should be very similar.

An investigation into the causes of this phenomenon determined that it may have been caused by static interference on the surface of the plastic vials containing the background samples when counted during a period of relatively dry air. As the background is the first vial counted in the assay design, there may not have been enough time to allow excessive static to dissipate from the vial before counting commenced. Technicians were made aware of these issues, and the problem has not recurred since.

4.3.3.4 Statement of Uncertainties Inherent in Monitoring Results

Uncertainties associated with SRBT groundwater monitoring may be present at certain points in the process.

The main uncertainties relate to standard measurement errors associated with liquid scintillation counting, and sample acquisition errors such as volume of drawn sample for analysis.

In order to provide assurance of accuracy and precision, SRBT conducted an intercomparison sampling and analysis activity with our primary contracted third party in May, as required by the GMP.

Five wells were sampled and measured by SRBT concurrently with the third party, with SRBT results averaging 99% of those obtained by the contracted service provider.

In addition, the protocols implemented by SRBT to determine tritium concentration in groundwater samples typically achieve an MDA of between 38-40 Bq/L, while third party measurements were reported with a limit of detection around 80 Bq/L.

The inherent uncertainties associated with groundwater monitoring are well within acceptable bounds when contrasted against the tritium concentrations that may present an unacceptable risk to the public.

4.3.3.5 Supplementary Studies

In addition to the comparative work performed in advancing the transition of GMP activities to SRBT, we have also provided collaborative support for a supplementary groundwater / subsurface soil study, championed by the University of Ottawa.

Soil core samples were obtained at depths of up to five metres from both the north side of the property along the line of sampling wells installed, and several dozen metres in the westerly direction of the site against the flow gradient of the aquifer.

The purpose of the sampling was to test the hypothesis that OBT can be activated in soil by simple isotopic exchange reactions between free water (HTO) and organic molecules. This may contribute to the understanding of OBT behaviour in the subsurface environment near sources of tritium.

Samples were acquired on May 16, 2017, with more than a year of study and analysis by the project lead with the University of Ottawa.

Preliminary data and analysis and were presented by the University of Ottawa project lead on September 25, 2018 at an international workshop on organically bound tritium in Toronto, Ontario[42]. Although the results of the study at the time of presentation were generally inconclusive, the study remains a work in progress.

4.3.3.6 Data Quality, Performance and Acceptance Criteria

Overall, the quality of data gathered as part of SRBT groundwater monitoring activities is successful in ensuring a high level of performance in monitoring, and in demonstrating that acceptance criteria (such as the limits on dose to the public) continue to be met.

All trip blanks, field duplicates, laboratory duplicates and quality control checks during liquid scintillation counting met performance criteria throughout 2018.

4.3.3.7 Program Objectives and Conceptual Site Model

The main objective of the GMP implemented by SRBT is to provide information to assess risks from site-affected groundwater to human health and the environment, ultimately to determine if the risk to the environment and the public from SRBT operations remains acceptably low.

One well monitored on a regular basis exceeds the Ontario Drinking Water Guideline value of 7,000 Bq/L. This well is a dedicated, engineered groundwater monitoring well very near to the facility within a secured area, and is not available to be used as a source of water consumption.

With respect to the conceptual site model, the highest average concentration of potable groundwater obtained from a residential well continues to show a generally stable or decreasing trend over time (see discussion in section 4.3.1.9 earlier in this report).

SRBT concludes that the comprehensive array of groundwater monitoring activities conducted continue to meet program objectives, and adheres to the conceptual site model developed as part of the Environmental Management System, as illustrated earlier in this report in Figure 7.

4.3.4 Other Monitoring

On occasion SRBT conducts monitoring of other environmental media in order to provide continued assurance of the safety of our operations.

4.3.4.1 Soil Monitoring

No soil monitoring was conducted in 2018.

4.3.4.2 Sludge Monitoring

In March and September 2018, SRBT collected samples of sludge cake from the Pembroke Pollution Control Centre.

Sludge data does not enter into calculation of public dose; however, given previously expressed stakeholder interest, SRBT has integrated sludge cake monitoring as part of the routine EMP activities.

All samples were collected and analyzed by an independent laboratory. The results obtained are tabled below:

TABLE 23: SLUDGE MONITORING

SAMPLE TYPE	MARCH 2018	SEPTEMBER 2018
FREE-WATER TRITIUM (Bq/L)	35 (+/-2)	44 (+/-4)
OBT FRESH WEIGHT (Bq/kg)	391 (+/-6)	448 (+/-18)

4.3.5 Public Dose

The calculation methods used to determine the dose to the representative persons as defined in the SRBT Environment Monitoring Program (EMP) are described in the in the program and in EMP-014, *Interpretation and Reporting Requirements for EMP Data.*

All data and tables relating to the calculation of the dose to the public can be found in **Appendix S**.

For 2018, the dose has been calculated using the effective dose coefficients found in Canadian Standards Association (CSA) Guideline N288.1-14[43].

TABLE 24: CSA GUIDELINE N288.1-14 EFFECTIVE DOSE COEFFICIENTS FOR H-3

AGE GROUP	EFFECTIVE DOSE COEFFICIENT – INHALATION (HTO) (μSv/Bq)	EFFECTIVE DOSE COEFFICIENT – INGESTION (HTO) (μSv/Bq)	EFFECTIVE DOSE COEFFICIENT – INGESTION (OBT) (μSv/Bq)
INFANT	8.0E-5	5.3E-5	1.3E-4
CHILD	3.8E-5	2.5E-5	6.3E-5
ADULT	3.0E-5	2.0E-5	4.6E-5

NOTE: The dose coefficients listed for inhalation account for skin absorption, as per Table C.1 of N288.1-14.

The dose assessed for the group of representative persons is a summation of:

- Tritium uptake from inhalation and absorption through skin at the place of residence and/or the place of work, ($P_{(i)19}$ and $P_{(e)19}$), and
- Tritium uptake due to consumption of well water (P_{29}), and
- Tritium uptake due to consumption of produce (P_{49}), and
- Tritium uptake due to consumption of dairy products (P_{59}).

Dose due to inhalation

The closest residence to SRBT is located by passive air sampler NW250 approximately 240 meters from the point of release. The 2018 average concentration of tritium oxide in air at passive air sampler NW250 has been determined to be **2.46 Bq/m^3**.

Three passive air samplers are located close to the SRBT facility and represent the tritium oxide in air ($P_{(i)19}$ and $P_{(e)19}$) concentrations for the representative person (adult worker) at samplers 1, 2, and 13. The sampler indicating the highest tritium oxide in air concentration is used to calculate the P_{19} dose values while at work. The highest average result for 2018 for PAS # 1, PAS # 2, and PAS # 13 is **4.58 Bq/m^3** at PAS # 1.

Using the inhalation rates found in CSA Guideline N288.1-14[44], and assuming 2,080 hours (23.744%) of work per year with 6,680 hours (76.256%) at home (a total of 8,760 hours per year):

TABLE 25: CSA GUIDELINE N288.1-14 INHALATION RATES

AGE GROUP	INHALATION RATE (m^3/a)
INFANT	2,740
CHILD	7,850
ADULT	8,400

$P_{(i)19}$: Adult worker dose due to HTO inhaled at residence

The average value for tritium oxide in air for the sampler taken as representing the place of residence for the defined representative person equals 2.46 Bq/m^3.

$P_{(i)19r}$ = [H-3_{air}] (Bq/m^3) x Resp. Rate (m^3/a) x Occup. Factor x DCF_{H3} (μSv/Bq)
= 2.46 Bq/m^3 x 8,400 m^3/a x 0.76256 x 3.0E-05 μSv/Bq
= 0.473 μSv/a

$P_{(i)19}$: Adult worker dose due to HTO inhaled at work

Taking the highest concentration between Passive Air Samplers #1, #2, and #13 is Passive Air Samplers #1 at 4.58 Bq/m^3.

$P_{(i)19w}$ = [H-3_{air}] (Bq/m^3) x Resp. Rate (m^3/a) x Occup. Factor x DCF_{H3} (μSv/Bq)
= 4.58 Bq/m^3 x 8,400 m^3/a x 0.23744 x 3.0E-05 μSv/Bq
= 0.274 μSv/a.

$P_{(i)19}$: Adult resident dose due to HTO inhaled at residence

The average value for tritium oxide in air for the sampler representing the place of residence for the defined representative person equals 2.46 Bq/m^3:

$$P_{(i)19} = [H\text{-}3_{air}]\ (Bq/m^3) \times Resp.\ Rate\ (m^3/a) \times DCF_{H3}\ (\mu Sv/Bq)$$
$$= 2.46\ Bq/m^3 \times 8{,}400\ m^3/a \times 3.0E\text{-}05\ \mu Sv/Bq$$
$$= 0.620\ \mu Sv/a$$

$P_{(i)19}$: Infant resident dose due to HTO inhaled at residence

The average value for tritium oxide in air for the sampler representing the place of residence for the defined representative person equals 2.46 Bq/m^3:

$$P_{(i)19} = [H\text{-}3_{air}]\ (Bq/m^3) \times Resp.\ Rate\ (m^3/a) \times DCF_{H3}\ (\mu Sv/Bq)$$
$$= 2.46\ Bq/m^3 \times 2{,}740\ m^3/a \times 8.0E\text{-}05\ \mu Sv/Bq$$
$$= 0.539\ \mu Sv/a$$

$P_{(i)19}$: Child resident dose due to HTO inhaled at residence

The average value for tritium oxide in air for the sampler representing the place of residence for the defined representative person equals 2.46 Bq/m^3:

$$P_{(i)19} = [H\text{-}3_{air}]\ (Bq/m^3) \times Resp.\ Rate\ (m^3/a) \times DCF_{H3}\ (\mu Sv/Bq)$$
$$= 2.46\ Bq/m^3 \times 7{,}850\ m^3/a \times 3.8E\text{-}05\ \mu Sv/Bq$$
$$= 0.734\ \mu Sv/a$$

Dose due to skin absorption

Beginning in 2016, the dose due to skin absorption is wholly accounted for by the application of the inhalation dose conversion factors applied above.

Please see CSA N288.1-14, Table C.1 footnotes for details on dose conversion factors and how they account for skin absorption.

Dose due to consumption of well water

The tritium uptake due to consumption of well water is calculated by taking the average tritium concentration of the water sampled.

Using the following annual consumption rates (at the 95th percentile) derived from information found in CSA Guideline N288.1-14[45]:

TABLE 26: CSA GUIDELINE N288.1-14 WATER CONSUMPTION RATES

AGE GROUP	WELL WATER CONSUMPTION RATE (L/a)
INFANT	305.7
CHILD	482.1
ADULT	1,081.1

In 2018, the highest concentration in a residential well used as the sole source of the drinking water was found in RW-8 at 204 Boundary Road, equal to **120 Bq/L**. This value will therefore be used in the calculation of the public dose.

P_{29}: Adult dose due to consumption of well water

P_{29} = $[H\text{-}3]_{well}$ x M x 2.0E-05 μSv/Bq;
= [120 Bq/L] x 1,081.1 L/a x 2.0E-05 μSv/Bq
= 2.595 μSv/a

P_{29}: Infant dose due to consumption of well water

P_{29} = $[H\text{-}3]_{well}$ x M x 5.3E-05 μSv/Bq;
= [120 Bq/L] x 305.7 L/a x 5.3E-05 μSv/Bq
= 1.944 μSv/a

P_{29}: Child dose due to consumption of well water

P_{29} = $[H\text{-}3]_{well}$ x M x 2.5E-05 μSv/Bq;
= [120 Bq/L] x 482.1 L/a x 2.5E-05 μSv/Bq
= 1.446 μSv/a

Dose due to consumption of produce

The tritium uptake due to consumption of produce, both locally purchased and home grown is calculated by taking the average tritium concentration of produce purchased from the local market and assuming the consumption of 70% of the annual total of produce from this source, and by taking the average tritium concentration from local gardens and assuming the consumption of 30% of the annual total of produce from this source.

These fractions are based upon the site-specific survey previously conducted by SRBT, which determined that the home-grown fraction of plant products consumed by residents in the surrounding area was approximately 30% - a slightly higher value than those recommended in the generic guidance of N288.1-14 (20-25%).

Using the following annual consumption rates for produce derived using information found in CSA Guideline N288.1-14[46]:

TABLE 27: CSA GUIDELINE N288.1-14 PRODUCE CONSUMPTION RATES

AGE GROUP	FRUIT CONSUMPTION RATE (Kg/a)	ABOVE-GROUND VEGETABLES CONSUMPTION RATE (Kg/a)	ROOT VEGETABLES CONSUMPTION RATE (Kg/a)	TOTAL CONSUMPTION RATE (Kg/a)
INFANT	76.6	36.1	12.1	124.8
CHILD	124.4	97.6	43.2	265.2
ADULT	149.2	192.3	71.8	413.3

The average tritium concentration in produce purchased from the sampled market in 2018 was **4.0 Bq/kg**, while the highest average concentration in produce from a local garden in 2018 was **141.0 Bq/kg** at 611 Moss Drive.

P_{49}: Adult dose due to consumption of produce (HTO)

$$
\begin{aligned}
P_{49HTO} &= [[H_{prod,market}] + [H_{prod,res}]] \times 2.0\text{E-}05\ \mu Sv/Bq \\
&= [[H\text{-}3_{veg}]\ (Bq/kg) \times (kg) \times 0.7] + [H\text{-}3_{veg}]\ (Bq/kg) \times (kg) \times 0.3]] \times 2.0\text{E-}5\ \mu Sv/Bq \\
&= [[4.0\ Bq/kg \times 413.3\ kg/a \times 0.7] + [141\ Bq/kg \times 413.3\ kg/a \times 0.3]] \times 2.0\text{E-}05\ \mu Sv/Bq \\
&= [[1{,}157\ Bq/a] + [17{,}483\ Bq/a]] \times 2.0\text{E-}05\ \mu Sv/Bq \\
&= 0.373\ \mu Sv/a
\end{aligned}
$$

P_{49}: Infant dose due to consumption of produce (HTO)

P_{49HTO} = [[$H_{prod,market}$] + [$H_{prod,res}$]] x 5.3E-05 μSv/Bq
= [[H-3_{veg}] (Bq/kg) x (kg) x 0.7] + [H-3_{veg}] (Bq/kg) x (kg) x 0.3]] x 5.3E-5 μSv/Bq
= [[4.0 Bq/kg x 124.8 kg/a x 0.7] + [141 Bq/kg x 124.8 kg/a x 0.3]] x 5.3E-05 μSv/Bq
= [[349 Bq/a] + [5,279 Bq/a]] x 5.3E-05 μSv/Bq
= 0.298 μSv/a

P_{49}: Child dose due to consumption of produce (HTO)

P_{49HTO} = [[$H_{prod,market}$] + [$H_{prod,res}$]] x 2.5E-05 μSv/Bq
= [[H-3_{veg}] (Bq/kg) x (kg) x 0.7] + [H-3_{veg}] (Bq/kg) x (kg) x 0.3]] x 2.5E-5 μSv/Bq
= [[4.0 Bq/kg x 265.2 kg/a x 0.7] + [141 Bq/kg x 265.2 kg/a x 0.3]] x 2.5E-05 μSv/Bq
= [[743 Bq/a] + [11,218 Bq/a]] x 2.5E-05 μSv/Bq
= 0.299 μSv/a

SRBT directly monitored organically bound tritium (OBT) concentrations in tomatoes in the garden at 408 Boundary Road, as well as from pumpkins from the commercial market garden. The average OBT concentration from the residential produce was measured as 4.0 Bq/kg, while for the commercial produce a value of 3.0 Bq/kg was measured.

P_{49}: Adult dose due to consumption of produce (OBT)

P_{49OBT} = [[$H_{prod,market}$] + [$H_{prod,res}$]] x 4.6E-05 μSv/Bq
= [[H-3_{veg}] (Bq/kg) x (kg) x 0.7] + [H-3_{veg}] (Bq/kg) x (kg) x 0.3]] x 4.6E-5 μSv/Bq
= [[3 Bq/kg x 413.3 kg/a x 0.7] + [4 Bq/kg x 413.3 kg/a x 0.3]] x 4.6E-05 μSv/Bq
= [[868 Bq/a] + [496 Bq/a]] x 4.6E-05 μSv/Bq
= 0.063 μSv/a

P_{49}: Infant dose due to consumption of produce (OBT)

P_{49OBT} = [[$H_{prod,market}$] + [$H_{prod,res}$]] x 1.3E-4 μSv/Bq
= [[H-3_{veg}] (Bq/kg) x (kg) x 0.7] + [H-3_{veg}] (Bq/kg) x (kg) x 0.3]] x 1.3E-4 μSv/Bq
= [[3 Bq/kg x 124.8 kg/a x 0.7] + [4 Bq/kg x 124.8 kg/a x 0.3]] x 1.3E-4 μSv/Bq
= [[262 Bq/a] + [150 Bq/a]] x 1.3E-4 μSv/Bq
= 0.054 μSv/a

P_{49}: Child dose due to consumption of produce (OBT)

P_{49OBT} = [[$H_{prod,market}$] + [$H_{prod,res}$]] x 6.3E-5 μSv/Bq
= [[H-3_{veg}] (Bq/kg) x (kg) x 0.7] + [H-3_{veg}] (Bq/kg) x (kg) x 0.3]] x 6.3E-5 μSv/Bq
= [[3 Bq/kg x 265.2 kg/a x 0.7] + [4 Bq/kg x 265.2 kg/a x 0.3]] x 6.3E-5 μSv/Bq
= [[557 Bq/a] + [318 Bq/a]] x 6.3E-5 μSv/Bq
= 0.055 μSv/a

Total dose due to consumption of produce:

P_{49}: Adult dose due to consumption of produce (HTO + OBT)

P_{49} = P_{49HTO} + P_{49OBT}
= 0.373 μSv/a + 0.063 μSv/a
= 0.436 μSv/a

P_{49}: Infant dose due to consumption of produce (HTO + OBT)

P_{49} = P_{49HTO} + P_{49OBT}
= 0.298 μSv/a + 0.054 μSv/a
= 0.352 μSv/a

P_{49}: Child dose due to consumption of produce (HTO + OBT)

P_{49} = P_{49HTO} + P_{49OBT}
= 0.299 μSv/a + 0.055 μSv/a
= 0.354 μSv/a

Dose due to consumption of local milk

The tritium uptake due to consumption of milk, from a local producer and distributor is calculated by taking the average tritium concentration of the milk sampled.

Using the following annual milk consumption rates derived using information found in CSA Guideline N288.1-14[46]:

TABLE 28: CSA GUIDELINE N288.1-14 MILK CONSUMPTION RATES

AGE GROUP	MILK CONSUMPTION RATE (kg/a)
INFANT	339.9
CHILD	319.6
ADULT	188.5

The average concentration in milk in 2018 was measured as 3.85 Bq/L; adjusting for the density of milk, a specific activity of 3.85 Bq/L x 0.97 L/kg = **3.735 Bq/kg** is calculated.

P_{59}: Adult dose due to consumption of milk

P_{59} = $[H\text{-}3]_{dairy}$ x M x 2.0E-05 μSv/Bq;
= [3.735 Bq/kg] x 188.5 kg/a x 2.0E-05 μSv/Bq
= 0.014 μSv/a

P_{59}: Infant dose due to consumption of milk

P_{59} = $[H\text{-}3]_{dairy}$ x M x 5.3E-05 μSv/Bq;
= [3.735 Bq/kg] x 339.9 kg/a x 5.3E-05 μSv/Bq
= 0.067 μSv/a

P_{59}: Child dose due to consumption of milk

P_{59} = $[H\text{-}3]_{dairy}$ x M x 5.3E-05 μSv/Bq;
= [3.735 Bq/kg] x 319.6 kg/a x 2.5E-05 μSv/Bq
= 0.030 μSv/a

Representative persons annual dose due to tritium uptake based on EMP

Based on the EMP results and the coefficients and parameters taken or derived from N288.1-14[43,44,45,46], the annual dose (P_{total}) due to tritium uptake from inhalation and skin absorption, consumption of local produce, local milk and well water equates to a conservatively calculated maximum of **3.792 µSv** for an adult worker representative person in 2018, compared to 3.349 µSv in 2017, 4.579 µSv in 2016, and 6.840 µSv in 2015.

TABLE 29: 2018 REPRESENTATIVE PERSONS ANNUAL DOSE BASED ON EMP

DOSE CONTRIBUTOR		ADULT WORKER ANNUAL DOSE (µSv/A)	ADULT RESIDENT ANNUAL DOSE (µSv/A)	INFANT RESIDENT ANNUAL DOSE (µSv/A)	CHILD RESIDENT ANNUAL DOSE (µSv/A)
DOSE DUE TO INHALATION and ABSORPTION AT WORK	$P_{(I)19}$	0.274			
DOSE DUE TO INHALATION and ABSORPTION AT RESIDENCE	$P_{(I)19}$	0.473	0.620	0.539	0.734
DOSE DUE TO CONSUMPTION OF WELL WATER	P_{29}	2.595	2.595	1.944	1.446
DOSE DUE TO CONSUMPTION OF PRODUCE	P_{49}	0.436	0.436	0.352	0.354
DOSE DUE TO CONSUMPTION OF MILK	P_{59}	0.014	0.014	0.067	0.030
2018 PUBLIC DOSE	P_{TOTAL}	**3.792**	3.665	2.902	2.564

Statement of Uncertainties in Calculation of Public Dose:

All parameters taken from N288.1-14 are at the 95th percentile where available. Actual ingestion and inhalation rates are likely to be lower for most of the population. Calculated doses are likely to be significantly higher than actual doses to persons as a result.

4.3.6 Program Effectiveness

The suite of SRBT environmental protection programs have continued to be effective in measuring tritium in the environment and at ensuring the prevention of unreasonable risk to the environment.

The Environmental Monitoring Program continues to be implemented effectively. The past year represents the second full year of operation since the program revision to comply with the requirements of CSA standard N288.4-10, and the program continues to be improved over time.

Our passive air sampling array is effective and provides a picture of the full extent of tritium concentrations in air resulting from the emissions from the facility, and in turn providing real data to accurately estimate the dose to representative persons resulting from the emissions from the facility.

Total air emissions in 2018 increased when compared to 2017, as did several indicators pertaining to the EMP. The increase of HTO trends alongside an observed increase in cumulative average of all PAS data as expected.

Tritium concentrations in residential wells, and in milk and produce that are consumed by residents living near the facility are measured. This data is effective at providing the full extent of tritium concentrations in human food and potable water sources resulting from the emissions from the facility, and in turn providing data to reliably estimate the dose to representative persons resulting from the emissions from the facility.

The Effluent Monitoring Program was also implemented very effectively in 2018, and succeeded in achieving the defined objectives of the program, including confirming the adequacy of controls on releases from the source, providing high-quality data, and demonstrating adherence to licence limits.

The Groundwater Monitoring Program was highly effective at providing data on the full extent of tritium concentrations in groundwater resulting from the emissions from the facility, and demonstrating the effectiveness of operational changes that have taken place over the last several years.

4.3.7 Program Review and Audit Summary

All major elements of the Environmental Management System (EMS) are scheduled to be audited at least once every three years.

Unfortunately due to an unexpected operational challenge that required a shift in internal resources (see section 1.2.7), the scheduled audit for 2018 was deferred into 2019.

The scope of the audit for 2019 will be expanded to include all which was to be audited in the 2018 calendar year. A non-conformance report was raised to document the issues pertaining to the missed audit in 2018, and corrective measures have been implemented to prevent recurrence.

4.3.8 CSA N288-series Gap Analysis

In 2015, SRBT undertook a gap analysis of the entire set of management system documentation associated with Environmental Protection against the available suite of CSA standards related to the subject. These standards included:

- CSA N288.4-10 – *Environmental monitoring at Class I nuclear facilities and uranium mines and mills*
- CSA N288.5-11 – *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*
- CSA N288.6-12 – *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*
- CSA N288.7-15 – *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills*

The final gap analysis document was submitted to CNSC staff on January 15, 2016[47], with an associated action plan designed as a multi-year project of improvement and assessment of all aspects of environmental protection associated with our operations.

Comments from CNSC staff were received on March 31, 2016[48], which were subsequently dispositioned through a new revision of the gap analysis / action plan document. This was provided to CNSC staff on May 26, 2016[49], and the plan has continued to be executed since then.

In 2018, SRBT developed the process for the conduct of Environmental Risk Assessments (ERA), in line with the continued execution of our N288-series action plan. The final major deliverable relating to the gap analysis is the conduct and issuance of a formal ERA, expected in late 2020.

4.3.9 Emission Reduction Initiatives

SRBT has a continual commitment to researching, developing and implementing initiatives aimed at reducing the emission of tritium to the environment associated with our licenced activities. We have committed to invest no less than 5% of the company annualized net profit back into emission reduction initiatives (based upon fiscal year profit figures, October 1 through September 30 each year).

In 2018, SRBT continued to allocate resources into several areas in order to adhere to this commitment and further reduce emissions. A description of these initiatives is provided here.

4.3.9.1 PUTT Design Improvements

In 2017, a prototype tritium trap base was manufactured for SRBT which incorporates several potentially improved characteristics into the component. A research and development plan was created as part of change control package ECR-790-CCP-01, and the prototype was put into service in November.

The new base design should result in a lower probability of thermally-induced base integrity failure over the course of the life cycle of the component, an event which can result in unplanned releases of tritium as gaseous effluent. The in-use design does not fail at an unacceptable rate; however, the potential improvement was deemed to be worth investigating.

The research and development plan was completed in 2018, with no significant safety risks or issues being uncovered during testing and analysis. A decision was made to authorize this design for use, and to begin to use the new design of base once the current stock of bases was exhausted.

4.3.9.2 Preventative Maintenance on Tritium Processing Equipment

The frequency of preventative maintenance on tritium processing equipment has continued to be managed in a way to contribute to reducing tritium releases.

Wearable process components such as valve stems had been placed on a revised schedule of replacement in 2017, moving away from ‘run-to-failure’ maintenance strategies; however, this strategy did not have the intended effect. Conversely, for many components, run-to-failure has been shown to be the preferable maintenance strategy due to the potential of damaging or disturbing other key process components when performing the replacement of the parts. As such, changes were incorporated into maintenance procedures to capture these lessons learned and to optimize maintenance strategies.

4.3.9.3 Band Heaters for Tritium Processing

A research and development plan was developed in 2016 to explore if band heaters may be an appropriate alternative trap heating source when processing tritium. From the perspective of emission reduction, the hypothesis is that a reduction in tritium oxide may be achieved by using band heaters during routine processing.

The final version of the plan was accepted in November 2016, with the intent to implement the active testing soon thereafter; however, due to competing research initiatives (specifically, tritium trap base design), this initiative was placed on hold, with an eye to return to this project at some point in the 2019-2020 timeframe.

4.4 SCA – Emergency Management and Fire Protection

As most potential hazards associated with the facility would result from fire, Emergency Management and Response for the facility are addressed by an extensive Fire Protection Program supported by an Emergency Plan.

4.4.1 Fire Protection

Various measures were taken at the facility in 2018 to improve fire safety. These activities included but were not limited to the following:

- Fire Protection Program (FPP) was revised and accepted by CNSC staff and the Pembroke Fire Department (PFD),
- Third party contractor completed a Site Condition Inspection at the facility (a detailed report was completed),
- Third party contractor completed an audit of the FPP (a detailed report was completed).
- The PFD completed an inspection of the SRBT facility,
- Provided employee fire safety training session,
- Annual fire safety and extinguisher training for all employees, provided by the PFD, and
- Enhanced training for one Fire Protection committee member.

4.4.1.1 Fire Protection Committee

In 2018, four formal Fire Protection Committee meetings were held which resulted in the implementation of several improvements for fire protection and life safety at the facility. All Fire Protection Committee meeting minutes are kept on file.

4.4.1.2 Fire Protection Program, Fire Safety Plan and Procedures

On September 19, 2018[33], SRBT submitted a revised Fire Protection Program and Fire Safety Plan to CNSC staff. Changes to both of these documents reflected findings and recommendations of internal audits. CNSC staff accepted both revised documents on November 8, 2018[34].

One new Fire Protection procedure was created, and numerous upgrades and minor revisions were made to internal existing procedures to enhance fire protection and life safety at the facility, in line with our policy of continuous improvement.

4.4.1.3 Sprinkler System Design Modification

On November 3, 2017[50], SRBT notified CNSC staff of a proposed change to the fire suppression system servicing the facility, where the installation of tamper switches and dual monitoring modules would replace the ‘lock and chain’ control mechanism on the main water supply valve to the building.

The change proposal was acknowledged by CNSC staff on December 20, 2017[51]. The detailed proposal underwent our engineering change control process, and was successfully implemented and verified effective on March 9, 2018.

4.4.1.4 Maintenance of the Sprinkler System

In 2018 quarterly and annual maintenance was performed on the sprinkler system by a third party. In addition, a weekly check of various valves and line pressures were performed by trained SRBT staff. All records are kept on file.

4.4.1.5 Fire Protection Equipment Inspections

In 2018, in-house routine inspection, testing and maintenance was performed on all fire protection and life safety equipment at the SRBT facility on a daily, weekly, monthly and annual basis by trained staff.

Qualified third party contractors also performed routine inspection, testing and maintenance of fire protection and life safety equipment at the SRBT facility. Annual inspection, testing and maintenance include fire extinguishers, emergency lighting, the fire panel and sprinkler system.

4.4.1.6 Fire Extinguisher Training

Annual fire extinguisher training was conducted with the support of the Pembroke Fire Department on October 31, 2018.

As in past years, the training was conducted using an electronic simulator, eliminating the risks associated with the controlled, repeated burning and extinguishing of liquid hydrocarbons as an environmentally-friendly measure.

The training also included a classroom-based session discussing personal safety when detecting a fire, the types of extinguishers available in the facility, and the proper and safe use of extinguishers when fighting fires.

4.4.1.7 Fire Protection Committee Member Training

The Fire Protection Committee continues to include a member who volunteers as a firefighter for a local fire department, and receives fire protection training from this department.

In August, the Fire Protection Specialist attended a 3-day hands-on training course focused on NFPA 13, Standard for the Installation of Sprinkler Systems.

In October, the Fire Protection Specialist attended a 3-day hands-on training course focused on NFPA 25, Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems.

Both of these NFPA-certified training activities were hosted by the Seneca College School of Fire Protection Engineering Technology in Toronto, Ontario.

4.4.1.8 Fire Alarm Drills

A total of seven in-house fire alarm drills were conducted in 2018.

Following each fire drill, supervisory staff and other personnel complete a Fire Alarm Drill Report. Each report is reviewed by the Fire Protection Committee and actions are taken as required to enhance fire and life safety at the facility.

4.4.1.9 Fire Protection Consultant Inspection and Audit

In November, a qualified third party (PLC Fire Safety Solutions) was contracted to complete an audit of the Fire Protection Program, as well as a Site Condition Inspection, in order to meet the operating licence requirements, including the requirements of CSA standard N393-13, *Fire protection for facilities that process, handle, or store nuclear substances*.

The scope of the audit and inspection was to evaluate the SRBT facility for compliance with the applicable inspection, testing and maintenance requirements of our operating licence.

The following codes and standards were reviewed for applicability to the specific systems at SRBT:

- NFCC-2010, *National Fire Code of Canada*
- NBCC-2010, *National Building Code of Canada*
- CSA standard N393-13, *Fire protection for facilities that process, handle, or store nuclear substances*.

Following the inspection, PLC prepared a “Site Condition Inspection Report”, from which one opportunity for improvement (OFI) was observed pertaining to storage heights in the shipping area. The OFI was acted upon immediately following the handover of the report.

As well, PLC prepared a “Fire Protection Program Audit Report”, from which one finding was observed pertaining to the inspection of exit doors used as means of egress that are not typically used on a daily basis. The finding will be addressed in early 2019 through the creation of a new FPP Procedure.

4.4.1.10 Pembroke Fire Department Inspection

The Pembroke Fire Department conducted a facility inspection to confirm compliance with the Ontario Fire Code in August, with no violations being identified.

4.4.2 Emergency Preparedness

SRBT ensures that we are prepared for an emergency at our facility. Staff, equipment and infrastructure are in place and ready to respond to an emergency in accordance with documented procedures.

4.4.2.1 Emergency Plan

The SRBT Emergency Plan has been developed based on the probability and potential severity of emergency scenarios associated with the operation of the facility.

The plan includes preparing for, responding to, and recovering from the effects of accidental radiological and/or hazardous substance releases from the SRBT facility.

The plan was last revised in 2017, and remains up-to-date for the facility's current state.

4.4.2.2 Emergency Exercises

In 2018 SRBT did not conduct an emergency exercise. The last full scale emergency exercise was conducted in 2015.

As per the Emergency Plan, SRBT conducts such exercises at least once every five years. The next exercise is projected to be conducted in 2020.

4.5 SCA – Waste Management

SRBT implements a Waste Management Program (WMP) that is aligned with the applicable requirements and guidelines in the following CSA Standards:

- CSA N292.0-14, *General principles for the management of radioactive waste and irradiated fuel*
- CSA N292.3-14, *Management of low- and intermediate-level radioactive waste*
- CSA N292.5-11, *Guideline for the exemption or clearance from regulatory control of materials that contain, or potentially contain, nuclear substances*

4.5.1 Radioactive Consignments – Waste

Ten shipments of low level waste (LLW) were made to Canadian Nuclear Laboratories in 2018.

Of these ten shipments, six included expired gaseous tritium light sources. A total of 220 Type A packages of expired gaseous tritium light sources were generated in 2018.

Seven of the ten shipments included tritium-contaminated waste materials generated by other processes, including material such as used protective clothing, used equipment components, crushed glass, filters, broken lights and cleaning material. One shipment included a package of expired tritium traps containing depleted uranium tritide.

The following table is provided as a summary of the low-level waste material that was generated and routed to a licenced waste management facility (CNL) in 2018.

TABLE 30: RADIOACTIVE WASTE CONSIGNMENTS (2018)

DATE	DESTINATION	CATEGORY	NUMBER OF PACKAGES and DESCRIPTION	TOTAL WEIGHT (Kg)	ACTIVITY (TBq)
Jan. 24, 2018	CNL	LLW	10 x UN2910 Pkgs	210	0.040
			1 x UN2910 Drum	70	0.010
Feb. 20, 2018	CNL	LLW	56 x UN2915 Pkgs	224	1,167.99
Apr. 4, 2018	CNL	LLW	7 x UN2910 Pkgs	147	0.028
			1 x UN2910 Drum	70	0.010
May 3, 2018	EnergySolutions	LLW	2 x UN2910 Drum	180	0.010
May 16, 2018	CNL	LLW	54 x UN2915 Pkgs	216	966.30
Jun. 6, 2018	CNL	LLW	5 x UN2910 Pkgs	105	0.020
			1 x UN2910 Drum	70	0.010
July 11, 2018	CNL	LLW	50 x UN2915 Pkgs	200	979.88
Aug. 8, 2018	CNL	LLW	8 x UN2910 Pkgs	168	0.032
			1 x UN2910 Drum	70	0.010
			1 X UN2915 Pkg	6	15.00
Oct. 11, 2018	EnergySolutions	LLW	2 x UN2910 Drum	180	0.010
Oct. 31, 2018	CNL	LLW	5 x UN2910 Pkgs	105	0.020
			1 x UN2910 Drum	70	0.010
			15 X UN2915 Pkg	60	281.40
Nov. 20, 2018	CNL	LLW	2 x UN2910 Pkgs	42	0.018
			21 X UN2915 Pkg	84	527.24
Dec. 19, 2018	CNL	LLW	2 x UN2910 Pkgs	42	0.018
			1 x UN2910 Drum	70	0.010
			24 X UN2915 Pkg	96	550.33

4.5.2 Storage of Radioactive Waste

Radioactive waste was stored on-site and inventory records of the waste were maintained. All packaged wastes were inspected monthly for potential off-gassing and container integrity.

4.5.2.1 Low-level Waste Interim Storage

Low-level waste (LLW) is any waste assessed as possessing activity levels that exceeds conditional clearance limits (for tritium), or in excess of the exemption quantities established in the Nuclear Substances and Radiation Devices Regulations (for all other radionuclides). Typical examples of such wastes are tritium-contaminated equipment or components, crushed glass, filters, broken lights, clean-up material, etc.

LLW was collected in various sealed receptacles, assessed, and ultimately placed into approved containers in the Waste Storage Room within Zone 3. Once sufficient material was collected, it was prepared for transfer to a licensed waste handling facility, using approved processes.

TABLE 31: INTERIM STORAGE OF LOW-LEVEL WASTE

AMOUNT IN STORAGE AT YEAR END 2017	AMOUNT GENERATED THROUGHOUT 2018	TRANSFERRED OFF SITE 2018	AMOUNT IN STORAGE AT YEAR END 2018
1 x 200 L drums	5 x 200 L drums	6 x 200 L drums	0 x 200 L drums
0.01 TBq	0.05 TBq	0.06 TBq	0.00 TBq

4.5.2.2 Clearance-level Waste Generation

Waste materials in Zone 2 and 3 that may be minimally contaminated and is likely to meet accepted clearance criteria is classified as very low-level waste (VLLW). This classification is temporary, as ultimately VLLW is assessed radiologically, and routed through one of two accepted disposal pathways – either as LLW or as clearance-level waste (CLW).

Examples of such materials are typically paper towels, gloves, disposable lab coats, shoe covers, and other such materials that are collected in various receptacles in the active areas of the facility. These materials are assessed, and should they meet the clearance criteria, disposed of via conventional pathways.

Through the first three quarters of 2018, the WMP clearance criteria applied to VLLW was 0.25 MBq/g, up to a maximum of 3,000 kg of cleared material per pathway. Any VLLW that was assessed as being less than this criteria was routed through accepted CLW pathways, such as landfill or recycling.

After submission of a revised analysis considering a change to our conditional clearance levels[31], a more restrictive radiological clearance level criterion was put in place beginning in October, in order to allow for a higher annual mass of waste to be routed through these pathways.

This was necessary as the plastic recycling pathway previously used has essentially been eliminated due to lack of market for the type of recycled materials. As a result, these items are now being routed to landfill.

The new WMP clearance criteria of 0.15 MBq/g, up to a maximum of 5,000 kg of cleared material per pathway, was accepted by CNSC staff as part of the review of Revision H of the Waste Management Program[32].

The mass of CLW generated in 2018 is tabulated below. Note that the practice of storage of CLW has been discontinued with the lack of a viable plastic recycling pathway. All CLW materials are now processed and disposed of within days of assessment.

TABLE 32: CLEARANCE-LEVEL WASTE (2018)

TYPE OF MATERIAL	PATHWAY	AMOUNT GENERATED (kg)
General waste, plastic	Landfill	3,130
Metal	Recycler	1,083

4.5.2.3 Phosphorescent Powder Waste

SRBT ships waste phosphorescent (zinc sulfide) powder (classified as mild environmental contaminant) to a licenced hazardous waste management contractor.

This waste is picked up quarterly, and disposed of in accordance with the requirements of the Ontario Ministry of Environment and Climate Change.

In 2018, 376 kg of this material was processed and safely disposed of through this program.

4.5.2.4 Waste Minimization

SRBT continues to minimize the generation of radioactive waste materials as part of our overall approach to waste management.

The Waste Management committee met once in 2018 to review and discuss initiatives that could ultimately minimize the amount of radioactive waste routed to licenced waste management facilities.

Continued segregation of material prior to bringing items into active zones remains effective at reducing waste materials that require management.

The implementation of Conditional Clearance Levels for waste materials has continued to be successful in reducing the amount of waste material that is needlessly disposed of as radioactive waste.

4.5.2.5 Expired Product Management

SRBT continues to offer return and disposal services to customers who possess expired tritium-illuminated devices, such as ‘EXIT’ signs.

In 2018, a total of 21,232 expired (or otherwise removed from service) self-luminous safety ‘EXIT’ type signs were accepted by SRBT from Canadian and American sources, representing a total activity of 3,530.29 TBq of tritium. For comparison, in 2017, 18,977 signs were processed representing 3,599.10 TBq of tritium.

As well, an additional 160.61 TBq of tritium was accepted from international origins (i.e. other than Canada and the United States) in the form of expired tritium illuminated devices, such as aircraft signs, dials, gauges and other smaller equipment. These were also processed for shipment to a licenced waste management facility.

Expired signs are disassembled safely and the light sources removed, in order to ensure that the volume of low-level radioactive waste that is generated is minimized. The expired lights are then packaged and shipped to a licenced radioactive waste management service provider.

A small number of these signs were evaluated as being fit for service in other applications, or having light sources that could be reused in other self-luminous devices. This practice is the only re-use of the lights and the tritium associated with these lights, and would represent a very small fraction of the total light sources managed. SRBT no longer ‘reclaims’ tritium gas from expired or non-conforming light sources, and has not done so since 2007.

4.6 SCA – Security

SRB Technologies (Canada) Inc. implements an accepted Facility Security Program for the facility, in accordance with CNSC regulatory requirements and expectations.

The program was reviewed, revised and submitted to CNSC staff on May 14, 2018[5].

SRBT did not experience any security-related events in 2018.

CNSC staff conducted an inspection of the SRBT Security Program and physical security systems in February. No compliance actions were identified, and two recommendations were dispositioned to the satisfaction of CNSC staff.

New staff members are required to qualify for a Facility Access Security Clearance (FASC), even if they are not expected to handle nuclear substances as part of their responsibilities. Individuals and contractors that visit the facility are required to also have an FASC or be escorted at all times by a staff member with a valid FASC.

Maintenance of the physical facility security system is performed by an independent third party at least every 6 months.

4.7 SCA – Safeguards and Non-Proliferation

SRBT possesses, uses, stores and manages an extremely small quantity of depleted uranium, which is a controlled nuclear substance.

This material is used as storage media for tritium gas on our processing equipment, a well-understood and widely-used strategy for manipulating and storing tritium in its gaseous, elemental state. By using depleted uranium in this fashion, we can ensure that the quantity of gaseous tritium being used during any given processing operation is restricted. This helps to ensure that the consequences of any unplanned event are minimized with respect to radiation and environmental protection, by ensuring that any release of tritium is limited.

The facility inventory of depleted uranium inventory increased by a total of 4.11 kg in 2018, as follows:

- As a result of a physical inventory assessment, the total inventory on site was adjusted by 4 grams in May, due to the identification and removal of several very small pebbles of other minerals in the stored material on hand.
- In August, a waste shipment of tritium trap bases that had reached their usage limit was performed. A total of 886 grams of depleted uranium was sent off site to a licensed waste management service provider.
- In October, new ‘virgin’ depleted uranium pellets were procured and delivered to the facility. A total of 5,000 grams of material was brought in to the facility.

At the conclusion of 2018, the total mass of depleted uranium on site stands at 9.678 kg. A limit of 10 kg of this material in inventory is applied as part of the operating limits and conditions in the SAR.

During 2018, the IAEA did not conduct verification activities of our inventory of this material, nor did the agency request any information on this matter. As a licensee, and pursuant to the *General Nuclear Safety and Control Regulations*, SRBT is fully committed to ensure that we meet all applicable regulatory requirements relating to Canada’s obligations relating to nuclear non-proliferation and safeguards.

Should a safeguards verification activity be requested or conducted, or a request for information made by the IAEA, SRBT will provide all accommodation to the agency and CNSC staff in order to satisfy our responsibilities in this safety and control area.

4.8 SCA – Packaging and Transport of Nuclear Substances

SRBT prepared, packaged and shipped all manufactured products containing nuclear substances in accordance with the *Packaging and Transport of Nuclear Substances Regulations.*

For the purpose of packaging and offering for transport, shipments of product designated as dangerous goods, SRBT must comply with the requirements of:

- CNSC
- IAEA
- International Air Transport Association (IATA)
- Transport Canada

The procedures used at SRBT are based on regulations and practices found in the following publications:

- Packaging and Transport of Nuclear Substances Regulations (PTNSR)
- IAEA Safety Standards Series - No. SSR-6
- Dangerous Goods Regulations (IATA)
- The TDG Compliance Manual: Clear Language Edition (Carswell)

Staff members involved with the packaging, offering for transport and receipt of dangerous goods are given Transportation of Dangerous Goods (TDG) training in accordance with the applicable regulations and are issued certificates by the employer.

4.8.1 Outgoing Shipments

In total, 948 consignments were safely shipped to various customers located in 22 countries around the world, including Canada.

A table is provided comparing the amount of outgoing shipments of our products over the past five years.

TABLE 33: OUTGOING SHIPMENTS OF PRODUCT (2014-2018)

Year	2014	2015	2016	2017	2018
Number of Shipments*	1,122	1,150	1,001	970	948
Number of Countries	19	16	18	23	22

*Note – SRBT often ships single palletized shipments of safety signs to the US which subsequently get broken down into multiple sub-consignments. These types of shipments are counted as a single consignment for the purposes of this table.

All outgoing shipments were conducted in compliance with all regulatory requirements pertaining to the transport of dangerous goods and / or nuclear substances. All packages were assessed for surface contamination prior to being offered for transport as required by SRBT procedures.

Information pertaining to the number of monthly outgoing shipments containing radioactive material for 2018 can be found in **Appendix T** of this report.

4.8.2 Incoming Shipments

In total, 518 consignments of radioactive shipments were received from various customers located in 7 countries around the world, including Canada. These returns held a total activity of 3,691 TBq of tritium.

The vast majority of the returned, expired devices were in the form of expired 'EXIT' signs that were destined to have the expired light sources removed and sent for storage at a licenced waste management facility.

A table is provided comparing the amount of incoming shipments of radioactive products have been made over the past five years.

TABLE 34: INCOMING SHIPMENTS OF RADIOACTIVE PRODUCT (2014-2018)

Year	2014	2015	2016	2017	2018
Number of Shipments	467	598	562	539	518
Number of Countries	10	9	9	6	7

All incoming shipments were received safely and in acceptable condition. Incoming packages containing nuclear substances are assessed for tritium leakage upon receipt.

Information pertaining to the number of monthly received shipments containing radioactive material for 2018 can be found in **Appendix U** of this report.

4.8.3 Reportable Event

SRBT made one report to CNSC staff pertaining to a failure to comply with the requirements of Section 26 of the *Packaging and Transport of Nuclear Substances Regulations* (PTNSR).

On February 5, SRBT offered a tritium storage container for transport that was later found to have contained a Type 'B' quantity of tritium in a package categorized as Type 'A'. This condition is non-compliant with Section 26 (2) of the PTNSR.

SRBT offered the package for transport to Canadian Nuclear Laboratories (CNL) from our facility in Pembroke. The package was transported by CNL carrier to their facilities that same day.

On February 28, SRBT was notified by the consignee that after conditioning of the tritide storage container, a volumetric quantity of gas was recovered which exceeded the Type 'A' quantity limits. As such, the shipment conducted on February 5 should have been classified as UN2916 (Type 'B') rather than UN2915 (Type 'A').

The package used to transport the tritide bed was the CNL 2060 'Tritide' package, certified to transport up to 18,500 TBq, under certificate CDN/2060/B(U)-85 (Rev. 6).

The package had been assembled and tested to specification as if it contained a Type 'B' quantity; however, the labelling and accompanying transport documents classified the shipment as UN2915, Type 'A'. The quantity of tritium contained in the package exceeded the Type 'A' limit of 40 TBq by a slight margin, but was well within the limit of the package as assembled and tested.

In order to prevent this type of administrative event from recurring in the future, SRBT has ceased shipping these containers as a Type 'A' quantity in a Type 'B' package, and instead now conservatively ship it labelled and documented as a Type 'B' shipment (UN2916).

The full report of this event[35] was provided to CNSC staff on March 14, 2018, with CNSC staff concluding that our actions were adequate[36] on March 16, 2018.

5. Other Matters of Regulatory Interest

5.1 Public Information and Disclosure

This section of the report will provide public information initiatives taken in 2018.

5.1.1 Direct Interaction with the Public

Historically almost all public inquiries occur during re-licensing. In 2018, there was one public non-local inquiry made by the Canadian Environmental Law Association who received Participant Funding from the CNSC, they requested documentation (environmental protection program, waste management program and preliminary decommissioning plan) and requested a prompt response due to an upcoming deadline to participate in the Regulatory Oversight Report meeting. A response was sent the same day as the request.

In 2018 we have sampled water from a number of wells belonging to the public every four months for tritium concentration. On a yearly basis we also sample produce from gardens belonging to members of the public for tritium concentration. We promptly provide each member of the public with a report of the sample results along with the anticipated radioactive exposure due to tritium from consuming either the water or produce. We provide members of the public a comparison of this exposure against the CNSC limit and against radioactive exposure from other known sources, such as cosmic radiation, x-rays, etc. No questions or comments were received.

Plant tours have proven to be a useful tool for SRBT to reach the public. In 2018 we have provided plant tours to 26 members of the general public (compared to 25 in 2018 and 27 in 2016) who had expressed interest in our facility.

In 2018 we provided plant tours to local representatives of:

- Renfrew County Community Futures Development Corporation,
- The City of Pembroke,
- Pembroke Fire Department,
- Industrial Research Assistance Program (IRAP),
- UL,
- Transport Canada,
- BDC,
- Renfrew County,
- FedDev, and
- Whitewater Township.

In 2018 as part of conducting our business in Pembroke we have also provided plant tours to local employee representatives of our existing and prospective suppliers of goods and/or services, including:

- Canadian Nuclear Laboratories,
- En-Plas,
- Manitoulin,
- McDougall Insurance,
- Layman Fire,
- Javelin, and
- Grow For You Inc.

In 2018 we also provided plant tours to existing and prospective customers including:

- Isolite,
- MB Microtec, and
- Suzuki

TABLE 35: PLANT TOURS (2018)

	2018
GENERAL PUBLIC	26
LOCAL INSTITUTIONS	10
LOCAL SUPPLIERS	7
CUSTOMERS	3
TOTAL	**46**

A public meeting was held by the CNSC on December 13, 2018 regarding the annual regulatory oversight report. During the meeting SRBT addressed questions regarding tritium in groundwater and lost time injuries. All questions were answered to the satisfaction of both the Commission and the CNSC Staff.

Again this year, the Public Information Committee discussed and agreed to not have a presentation to Pembroke City Council in 2018, nor to initiate a public opinion survey in 2018 (though the survey is available on our website) due to no concerns being voiced. Both decisions will be revisited in 2019.

On November 21, 2018 SRBT sent letters to five aboriginal groups. The letter first introduced and gave a description of SRBT. We noted that we had reached out to them back in 2014 as part of our licence renewal. We then offered a meeting and a tour of the facility. We stated we are fully committed to building a relationship with them. We sent a brochure and suggested they look at our website for more information. As of the end of 2018 we had not received a response.

During 2018, the President of SRBT made presentations to members of the public:

- The President of SRBT is a member of the Pembroke Economic Development Advisory Committee (PEDAC), attending monthly meetings where updates on SRBT are often discussed.
- The President of SRBT is also a member and chair of the Community Improvement Plan (CIP), attending meetings and discussing SRBT on occasion. The Mayor of Pembroke is also on the Committee.
- The President and Vice President of SRBT were invited to speak at the Algonquin Waterfront campus about the facility to several entrepreneurs during the pitch workshop for the Renfrew CFDC RC100. The President was asked to be a member of the Power Panel who chooses the top 3 finalists who advance in the competition in hopes they win the grand prize of a start-up opportunity for their business.

5.1.2 Program Revision

Revision 9 of the Public Information program (PIP) continues to demonstrate SRBT's commitment to openness and transparency. In 2019, there will be a review of the PIP to determine if changes or improvements can be made to better include non-local stakeholders etc. and also to review REGDOC 3.2.1, *Public Information and Disclosure*, which supersedes RD-99.3, and verify compliance

5.1.4 Program Audit

There were no internal audits conducted on the Public Information Program in 2018. The next internal audit is scheduled for July 2019.

5.1.5 Public Information Committee

The Public Information Committee held four formal meetings in 2018. Key subjects discussed including updates to our groundwater brochure, the general information brochure and pamphlet, all of which were updated on March 28, 2018 to reflect the data in the 2017 Annual Compliance Report, and were subsequently posted on our website.

The committee also discussed SRBT social media posts, letters sent to residences and businesses, funding the Science Fair, the CNSC public meeting, Emergency Response Personnel Training, letters sent to Aboriginal groups, and public perception.

5.1.6 Website and Social Media

SRBT operates a website at www.srbt.com, which continues to provide current environmental monitoring data, information about tritium, content on emergency preparedness, the safe transport of tritium to the facility and products from the facility, how to safely dispose of products, and the Licence and Licence Condition Handbook. The main page provides a number of possible information sources for the public on tritium and radiation exposure.

The Emergency Plan, the Preliminary Decommissioning Plan, CNSC Inspection reports, the 2017 Annual Compliance Report, the CNSC annual regulatory oversight report, and several community involvement donations were posted on the website during 2018.

We also maintain a Facebook, Instagram and Twitter account which are all updated periodically.

Since being initiated on February 3, 2015 our Facebook account has gained a total of 246 followers (40 in 2018), we made a total of 36 posts (12 in 2018) and received 18 reviews to date (3 in 2018) all of which are positive with a total of 242 page “likes’ (38 in 2018).

Since its inception on December 11, 2016, our Instagram account has gained a total of 139 followers (46 in 2018), we made a total of 18 posts (9 in 2018) and received an average of 29 likes per post in 2018.

Our Twitter account was started on April 6, 2017 and has since gained 43 followers (16 in 2018), we made a total of 11 posts (6 in 2018) and received 48 “likes” (26 in 2018).

5.1.7 Community Support

SRBT has supported the local community by providing support to various organizations and causes.

SRBT is a gold level corporate and club member of the Muskrat Watershed Council (MWC) in support of the water quality monitoring data report and ongoing work.

The Manager – Health Physics and Regulatory Affairs is a member of the Algonquin College Radiation Safety Program Advisory Committee. During the summer of 2018, SRBT employed a summer student from this program, and in turn that student continues working part time while still attending school.

SRBT is a member of the Upper Ottawa Valley Chamber of Commerce.

SRBT has supported the Main Street Community Services who provides research based programs for children with special needs.

SRBT has supported causes such as Community Living Upper Ottawa Valley, Bernadette McCann House for Women, the Renfrew County Poverty Action Network (CPAN) Festival of Trees and The Robbie Dean Family Counseling Center.

SRBT also supports Festival Hall the local community theater, the Alice and Fraser Horse Association and the Renfrew County Regional Science and Technology Fair.

SRBT supported the Zombie Thrill run in support of The Robbie Dean Family Counseling Center as well as the “End of Summer with a Song” with Brett Kissel to raise money for a local school.

SRBT sponsored and put in a team for the Upper Ottawa River Race & Paddle Festival in support of CHEO. SRBT for the second year in a row took home the trophy for the Celebrity Relay Race.

SRBT sponsored the Renfrew CFDC Winner Announcement night for the RC100 pitch finals.

SRBT also sponsors many sports teams and groups, including 2 local hockey teams, 2 fishing teams, 2 baseball teams, a volleyball team and a basketball team.

SRBT sponsored two fishing tournaments and a golf tournament.

5.2 Preliminary Decommissioning Plan and Financial Guarantee

The SRBT Preliminary Decommissioning Plan (PDP) and Financial Guarantee last underwent a significant revision in 2014-15 prior to licence renewal, and was accepted by the Commission on June 29, 2015 with the renewal of the SRBT operating licence for a period of seven years. The next revision of the PDP is scheduled for 2019.

The SRBT Financial Guarantee is a cash fund held in escrow, and does not rely on any letters of credit, bonds, insurance or other expressed commitments.

In 2015, third party consultants directly involved with the decommissioning of similar facilities determined that the projected decommissioning cost for the SRBT facility was $652,488. In order to ensure the financial guarantee was fully funded, a series of six equal installments were scheduled to be made over a three year period, beginning in October 2015, as part of the renewal of our operating licence.

Historical annual inflationary indexes are typically below the annual accrued interest rate of the Escrow Account; as such, SRBT proposed that all accrued interest in the existing Escrow Account remain in that account and be used to address inflationary indexing.

In 2018, SRBT made the final required installment[52]; as of April 24, 2018, $677,675.91 was held in escrow, meaning that the fund value represented 103.9% of the projected decommissioning cost for the facility, and the funds have continued to build interest over time. CNSC staff acknowledged that the payment schedule has been completed and that the financial statement meets requirements on May 16, 2018[53].

At the conclusion of 2018, the financial guarantee maintains a balance of $686,996.27, and continues to accrue interest over time. The financial guarantee remains valid, in effect and adequate to fund the decommissioning of the facility.

6 Improvement Plans and Forecast

6.1 Emission Reduction Initiatives

SRBT continues to explore ways toward reducing tritium emissions from the facility, as per our continuing commitment to environmental protection and the ‘as low as reasonably achievable (ALARA) philosophy. We have committed to invest no less than 5% of the company annualized net profit back into emission reduction initiatives (based upon fiscal year profit figures, October 1 through September 30 each year).

We continue to research improvements into the design and handling of our tritium traps, through which we have achieved significant reductions in tritium releases in the past two years.

In 2018, after concluding a research project, a new design of tritium trap base was approved for use as an improvement on the current design. The full roll-out of these new bases is expected to take place over the next two years.

The prospect of introducing the use of band heaters as the heat source when processing tritium remains in the research phase, which, after a brief pause to focus resources on other safety-related issues, is expected to resume in the 2019-2020 timeframe.

The Manager – Health Physics and Regulatory Affairs is scheduled to attend a technical conference in Busan, South Korea in the spring of 2019. Hosted by the Korean National Fusion Research Institute and supported by the American Nuclear Society, *Tritium 2019* is a triennial conference that showcases the latest tritium-related research and technology, including environmental behaviour and impacts, emissions control and health physics aspects.

6.2 Safety Performance Targets for 2019

For the coming year, SRBT Senior Management has approved a set of performance targets, which will be tracked and reported on as part of the 2019 ACR.

The following table documents the safety performance targets for SRBT in 2019:

TABLE 36: SRBT SAFETY AND PERFORMANCE TARGETS FOR 2019

PARAMETER	2019 TARGET
Maximum Worker Dose	≤ 0.70 mSv
Average Worker Dose	≤ 0.055 mSv
Calculated Dose to Member of the Public	≤ 0.0060 mSv
Total Tritium Emissions to Atmosphere (per week average)	≤ 650 GBq / week
Ratio – Tritium Emissions vs. Processed	≤ 0.13
Total Tritium Emissions – Liquid Effluent Pathway	≤ 10 GBq
Action Level Exceedances – Environmental	≤ 1
Action Level Exceedances – Radiation Protection	≤ 1
Contamination Control – Facility-wide Pass / Fail Rate	≥ 95%
Lost Time Injuries	0
Minor Injuries Reportable To Employment and Social Development Canada (ESDC)	≤ 15

6.3 Planned Modifications and Foreseen Changes

The upcoming year of operation is not expected to involve significant modifications to the facility or our licensed activities, and production levels are expected to remain stable.

We have seen a number of modifications and changes to our operations and our management system since licence renewal. We project that the coming year will be relatively static in terms of our operations and management.

That being said, the following key management system programs or documents are expected to be revised and submitted in 2019, and subsequently reviewed and accepted by CNSC staff:

- Maintenance Program,
- Regulatory Limits, Action Levels and Administrative Limits
- Fire Protection Program,
- Public Information Program, and
- Preliminary Decommissioning Plan

We will also begin implementing our process for the conduct of an environmental risk assessment (ERA), as part of the N288-series action plan[49]; this process is expected to take nearly two years to complete, culminating in the submission of an ERA report to CNSC staff that will support licence renewal in the 2021-22 timeframe.

SRBT will be continuing to explore increasing the amount of sampling and analysis done in-house in support of the EMP. We plan on conducting intercomparison work towards commencing passive air sampling and precipitation monitoring in 2019.

SRBT will continue to pursue and explore opportunities to reduce emissions in all forms, as part of our ongoing commitment to ensure that our environmental impacts are as low as reasonably achievable.

7 Concluding Remarks

Throughout the year, the management and staff of SRBT complied with all regulatory requirements and the conditions of our operating licence.

The year 2018 represented the second full year of operation under the new, N286-compliant management system, which remains effective at achieving our operational and safety-related goals. We continue to adjust and improve our processes in support of the safe and effective operation of our facility, and we continue to use operating experience to continuously improve the system.

Our facility remains within its designed safety basis, and continues to be fit for service. Key structures, systems and components have continued to be maintained diligently and effectively throughout 2018 through the implementation of our Maintenance Program.

Exposures to ionizing radiation to both workers and members of the public continue to remain low, and are far less than the regulatory limits prescribed. The local environment has remained protected, and the already low level of impact of our operations continues to be reduced over time, as we continue to implement best practices each and every day. Licence limits for our nuclear substance effluent streams continue to be respected with significant margin.

No lost time injuries occurred in 2018, which is in line with previous years, save for 2017 when we unfortunately experienced three such events. The fact that no such injuries took place in 2018 is a testament to the value of the lessons learned from the events the year previous, as well as the effectiveness of the corrective measures put in place.

Security of the facility and all nuclear substances was maintained at all times. One reportable event occurred with respect to the packaging and transport of nuclear substances, which was ultimately resolved with corrective actions that were accepted by CNSC staff.

SRBT remains well protected from fire hazards, and have maintained an accepted plan should an emergency condition arise. Our Public Information Program fully satisfies the requirements of the CNSC, and we continue to look for new ways to reach out into our local community in a positive and constructive fashion.

We continue to effectively manage all forms of waste generated by our operations, and continue to look to minimize the amount of waste that must be managed and controlled.

Our decommissioning responsibilities are documented and accepted, and our financial guarantee is fully funded. Although we plan on operating the facility for at least the next two decades, if not longer, having a complete, self-funded financial guarantee is an additional testament to our commitment of being a good community partner.

Safety and excellence in operations shall always remain as the number one overall priority in everything we do, and 2018 was a direct reflection of the success at achieving these goals. We will continue to improve our operations and minimize our impact on people and the environment as our company continues to sustainably grow over the coming years.

8 References

[1] Nuclear Substance Processing Facility Operating Licence NSPFOL-13.00/2022, valid from July 1, 2015 to June 30, 2022.

[2] Licence Condition Handbook – SRB Technologies (Canada) Inc. Nuclear Substance Processing Facility Operating Licence NSPFOL-13.00/2022 (e-Doc 4624621 (Rev. 0), 4899130 (Rev.1), 5127037 (Rev. 2)).

[3] Annual Compliance Monitoring and Operational Performance Reporting Requirements for Class 1B Nuclear Facilities (CNSC e-Doc 3471152); provided via email to J. MacDonald (SRBT) by J. Campbell (CNSC), February 17, 2016.

[4] Letter from M. Beaudette (CNSC) to S. Levesque (SRBT), *Type II Security Inspection conducted February 8, 2018 at SRB Technologies (Canada) Inc. 320-140 Boundary Road, Pembroke ON, Report# 18-NSD-SRB-01:,* dated March 19, 2018 (e-Doc 5482837).

[5] Letter from S. Levesque (SRBT) to M. Beaudette (CNSC), *Type II Security Inspection conducted February 8, 2018 at SRB Technologies (Canada) Inc. 320-140 Boundary Road, Pembroke ON, Report# 18-NSD-SRB-01:,* dated May 14, 2018.

[6] Letter from R. Buhr (CNSC) to S. Levesque (SRBT), *SRB Technologies (Canada) Inc. Inspection Report No. SRBT-2018-02 March 13, 2018,* dated June 5, 2018 (e-Doc 5546692).

[7] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *SRBT Response to Inspection Report SRBT-2018-02,* dated August 8, 2018.

[8] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRBT's Response to Inspection Report SRBT-2018-02,* dated August 27, 2018 (e-Doc 5619565).

[9] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Revised Radiation Safety Program (Revision L),* dated January 8, 2018 (e-Doc 5425400).

[10] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *Submission of Radiation Safety Program, Revision L,* dated October 31, 2017.

[11] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *Disposition of CNSC Staff Comments on Radiation Safety Program (Rev. L) and Submission of Rev. M,* dated January 19, 2018.

[12] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Disposition of Comments on its Revised Radiation Safety Program (Revision L),* dated February 1, 2018 (e-Doc 5447399).

[13] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Disposition of Comments on the Safety Analysis Report, Revision 4,* dated January 12, 2018 (e-Doc 5430845).

[14] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *Disposition of Comments on Safety Analysis Report, Rev. 4,* dated November 10, 2017.

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[15] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *Submission of SRBT Quality Manual, Revision K,* dated January 29, 2018.

[16] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Quality Manual Revision K,* dated January 31, 2018 (e-Doc 5445591).

[17] Email from J. MacDonald (SRBT) to R. Rashapov (CNSC), *SRBT Submission of Revised Procedures,* dated March 27, 2018.

[18] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Review of SRB Technologies (Canada) Inc.'s Revised Procedures: Tritium Inventory Management (Revision L) & Nuclear Substances Inventory Management (Revision C),* dated May 16, 2018 (e-Doc 5529632).

[19] Letter from H. Tadros (CNSC) to S. Levesque (SRBT), *SRB Technologies (Canada) Inc.'s Nuclear Substance Processing Facility Implementation of REGDOC-3.1.2, Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills,* dated February 23, 2018 (e-Doc 5457612).

[20] Letter from S. Levesque (SRBT) to H. Tadros (CNSC), *SRBT Implementation of REGDOC 3.1.2,* dated April 12, 2018.

[21] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *Submission of Revised Waste Management Program,* dated April 12, 2018.

[22] Email from R. Rashapov (CNSC) to J. MacDonald (SRBT), *RE: Submission of Waste Management Program (Revision G),* dated May 15, 2018.

[23] Email from J. MacDonald (SRBT) to R. Rashapov (CNSC), *RE: Submission of Waste Management Program (Revision G),* dated May 18, 2018.

[24] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Revised Waste Management Program (Revision G),* dated June 12, 2018.

[25] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *Submission of Revised SRBT Training Program Manual,* dated May 25, 2018.

[26] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Revised Training Program Manual,* dated June 18, 2018 (e-Doc 5557585).

[27] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *Disposition of CNSC Staff Comments on SRBT Training Program Manual (Rev. C),* dated July 4, 2018.

[28] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRBT's Disposition of Comments on the Training Program Manual (Revision C),* dated August 27, 2018 (e-Doc 5620200).

References continued…

[29] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *Submission of Revised SRBT Training Program Manual,* dated September 19, 2018.

[30] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Revised Training Program Manual (Revision D),* dated October 5, 2018 (e-Doc 5650121).

[31] Letter from S. Levesque (SRBT) to R. Rashapov (CNSC), *Submission of Revised Waste Management Program with Modified Conditional Clearance Levels,* dated August 24, 2018.

[32] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Revised Waste Management Program with Modified Conditional Clearance Levels,* dated October 5, 2018 (e-Doc 5650161).

[33] Letter from R. Fitzpatrick (SRBT) to R. Rashapov (CNSC), *Submission of Revised SRBT Fire Protection Program and Fire Safety Plan,* dated September 19, 2018.

[34] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff's Review of SRBT's Revised Fire Protection Program and Fire Safety Plan,* dated November 8, 2018 (e-Doc 5695796).

[35] Email from J. MacDonald (SRBT) to R. Rashapov (CNSC), *Full Report - Failure to Comply with Requirements of Section 36 of the PTNSR*, dated March 14, 2018.

[36] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Full Report – Failure to Comply with Requirements of Section 26 of the Packing and Transport of Nuclear Substances Regulations (February 28, 2018),* dated March 16, 2018 (e-Doc 5484234).

[37] Letter from M. Tremblay (Health Canada) to J. MacDonald (SRBT), *Certificate of Achievement,* dated June 18, 2018.

[38] Email from J. MacDonald (SRBT) to T. Barr (CNSC), *2017 Annual Compliance Report – 11341-3-18.3,* dated February 14, 2018.

[39] SRBT *Licence Limits, Action Levels and Administrative Limits*, Revision E, November 14, 2014.

[40] SRBT *Environmental Monitoring Program*, Revision B, August 12, 2016.

[41] Ontario Ministry of the Environment, *Certificate of Approval Air,* number 5310-4NJQE2, August 31, 2000.

[42] *Activation of OBT by Tritiated Water in Soil,* presentation by A. Shkarupin (University of Ottawa) at the 7th International Organically Bound Tritium (OBT) Workshop, September 25, 2018.

[43] CSA standard N288.1-14 , *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities,* Tables C.1, C.2.

[44] CSA standard N288.1-14 , *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities,* Table 19.

References continued…

[45] CSA standard N288.1-14 , *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities,* Table 21.

[46] CSA standard N288.1-14 , *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities,* Table G.9c.

[47] Letter from S. Levesque (SRBT) to M. Rinker (CNSC), *Environmental Protection Gap Analysis and Action Plan,* dated January 15, 2016.

[48] Letter from J. Campbell (CNSC) to S. Levesque (SRBT), *SRB Technologies (Canada) Inc's Gap Analysis – Regulatory Requirements and Standards for Environmental Management and Protection,* dated March 31, 2016 (e-Doc 4967340).

[49] Letter from S. Levesque (SRBT) to R. Buhr (CNSC), *Disposition of Comments – SRBT Environmental Protection Gap Analysis and Action Plan,* dated May 26, 2016.

[50] Letter from R. Fitzpatrick (SRBT) to R. Rashapov (CNSC), *Notification of Change to Fire Suppression System,* dated November 3, 2017.

[51] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Notification of Planned Change to the Fire Suppression,* dated December 20, 2017.

[52] Email from J. MacDonald (SRBT) to R. Rashapov (CNSC), *Decommissioning Escrow Account Deposit – April 2018,* dated April 25, 2018.

[53] Letter from R. Rashapov (CNSC) to S. Levesque (SRBT), *CNSC Staff Review of SRB Technologies (Canada) Inc.'s Decommissioning Account Deposit – April 2018,* dated May 16, 2018 (e-Doc 5529171)

9 Appendices

DESCRIPTION	LETTER
Tritium Activity on Site During 2018	A
Equipment Maintenance Information for 2018	B
Ventilation Equipment Maintained in 2018	C
Radiological Occupational Annual Dose Data for 2018	D
Swipe Monitoring Results for 2018	E
Passive Air Sampler Results for 2018	F
Wind Direction Graphs for 2018	G
Precipitation Monitoring Results for 2018	H
Receiving Waters Monitoring Results for 2018	I
Runoff Monitoring Results for 2018	J
Produce Monitoring Results for 2018	K
Milk Monitoring Results for 2018	L
Wine Monitoring Results for 2018	M
Weather Data for 2018	N
Well Monitoring Results for 2018	O
Gaseous Effluent Data for 2018	P
Liquid Effluent Data for 2018	Q
Compilation of Water Level Measurements for 2018	R
Data and Calculations for Public Dose in 2018	S
Outgoing Shipments Containing Radioactive Material for 2018	T
Incoming Shipments Containing Radioactive Material for 2018	U

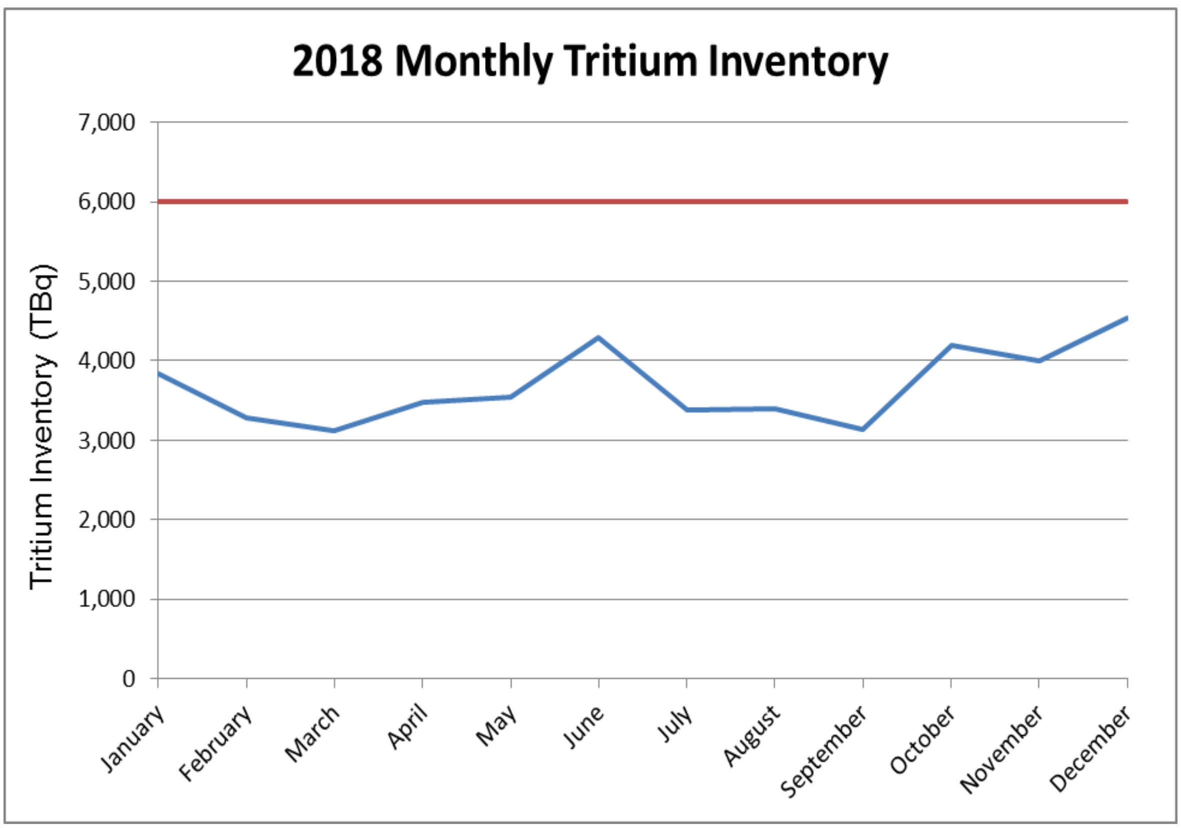
APPENDIX A

Tritium Activity on Site During 2018

TRITIUM ACTIVITY ON SITE DURING 2018

Month	Month-end H-3 Activity On-Site (TBq)	Percent of Licence Limit (%)
January	3,841	64.0%
February	3,279	54.7%
March	3,118	52.0%
April	3,474	57.9%
May	3,547	59.1%
June	4,294	71.6%
July	3,387	56.5%
August	3,394	56.6%
September	3,133	52.2%
October	4,194	69.9%
November	4,000	66.7%
December	4,531	75.5%
2018 Monthly Average	***3,683***	61.4%

Note: Tritium possession limit = 6,000 TBq.



APPENDIX B

Equipment Maintenance Information for 2018

2018 Scheduled Maintenance Activities Performed

Semi-Annual maintenance on HVAC equipment: **Contract:** Ainsworth	April 25, 2018 Sept 25, 2018
Quarterly maintenance on Rig & Bulk stack units: **Contract:** Ainsworth	March 29, 2018 June 11, 2018 Sept 17, 2018 Dec 18, 2018
Annual stack verification by a third party on Rig & Bulk stack units: **Contract:** Tab Inspection	Sept 27, 2018
Sprinkler System quarterly maintenance by a third party: **Contract:** Drapeau Automatic Sprinkler Corp	March 15, 2018 June 12, 2018 Sept 11, 2018 Dec 14, 2018
Emergency Lighting & Fire Extinguisher annual inspection by a third party: **Contract:** Layman Fire and Safety	March 20, 2018
Sprinkler System inspection by SRBT:	Weekly
Fire Alarm Components inspection by SRBT:	Weekly
Fire Separation doors inspection by SRBT:	Weekly
Fire Extinguisher inspection by SRBT:	Monthly
Emergency Lights inspection by SRBT:	Monthly
Quarterly maintenance carried out on the compressor: **Contract:** Valley Compressor	Jan 11, 2018 Mar 2, 2018 April 24, 2018 July 16, 2018 Oct 17, 2018
Fumehood Inspections by SRBT:	Monthly
Tritium-in-Air Sample Collector Bubblers maintenance:	Bi-monthly
Tritium-in-Air Sample Collector Bubblers third party annual verification: **Contract:** Canadian Nuclear Laboratories	Feb 20, 2018
Liquid Scintillation Counters third party annual maintenance: **Contract:** PerkinElmer	Oct 16, 2018
Real-time Stack Monitoring system verification by SRBT:	March 15, 2018 June 5, 2018 Sept 19, 2018 Dec 5, 2018
Monitoring well inspection by SRBT:	Feb 28, 2018 June 1, 2018 Oct 1, 2018
Annual IT maintenance inspection by SRBT:	September 28, 2018
Non-active air filter inspection by SRBT:	Monthly
Annual Zone Differential Pressure Test by SRBT:	December 20, 2018
Report of any weakening or possible major failure of any components:	None

All ventilation systems were maintained at a high fitness for service. Corrective maintenance was performed as required. Ventilation equipment maintenance was performed under contract with a fully licensed maintenance and TSSA certified local HVAC contract provider.

All process equipment is serviced and maintained by qualified staff and through contract with companies that specialize in process control systems. All process equipment has been maintained in fully operational condition. Corrective maintenance was performed on equipment as required as a result of as found conditions during inspections and is recorded.

APPENDIX C

Ventilation Equipment Maintained in 2018

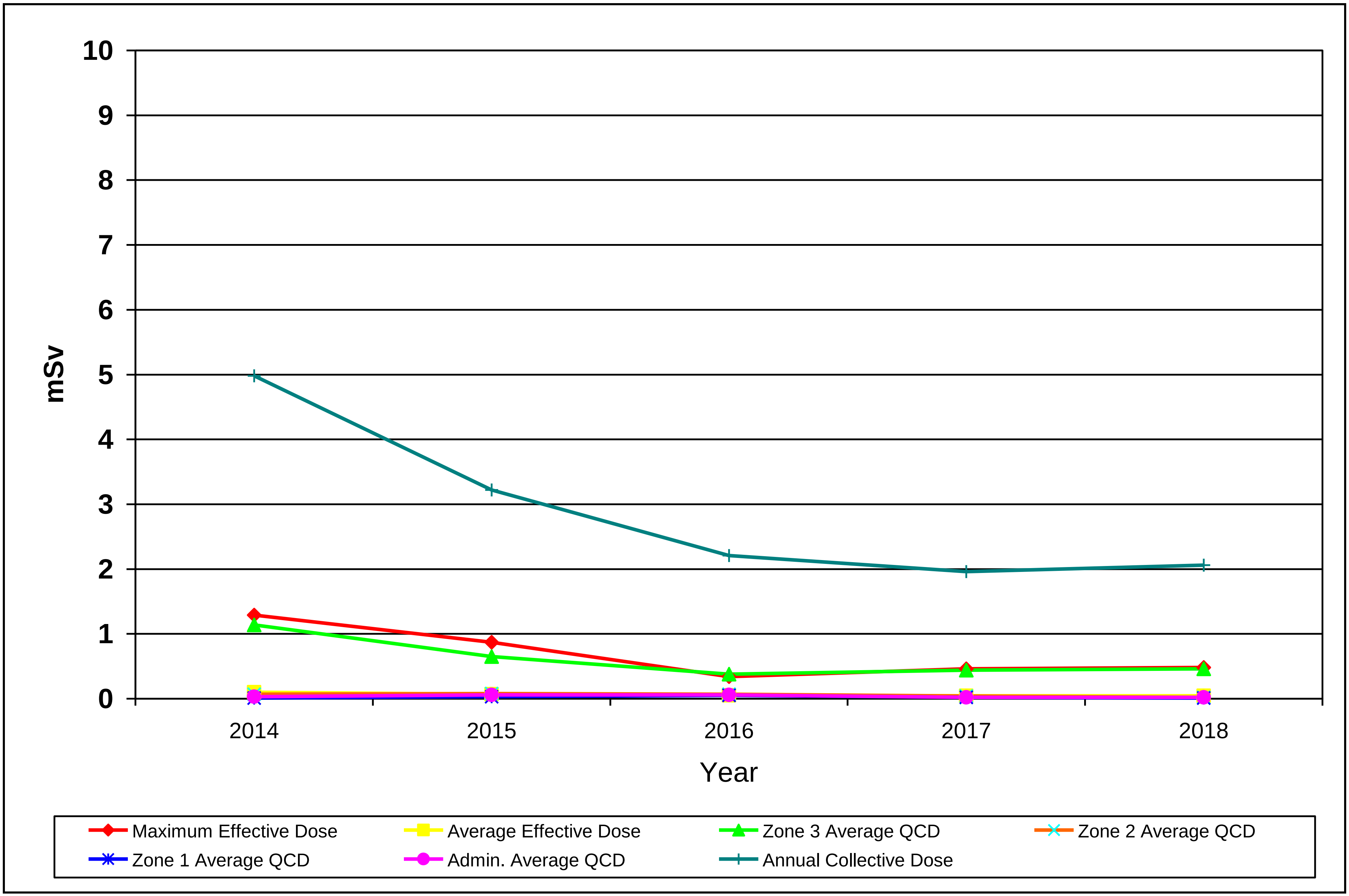
Ventilation Equipment Maintained In 2018

Y	TYPE	ZONE SERVICED	LOCATION OF UNIT
1	Gas Furnace	1	Front office / server hallway
1	Mid efficient gas furnace	1	Receiving area
1	Mid efficient gas furnace & central air	1	Stores
1	Mid efficient gas furnace	1	Back bay
1	Heat Recovery unit	1	Receiving area
1	HRV with reheat	2	Coating
2	Makeup air units	1 & 2	Coating room
3	Unit heaters	1 & 3	Rig room, Glass shop, Receiving area
1	A/C wall unit	1	Glass shop
4	Exhaust fans	1 & 2	Coating, Assembly, Glass room, Paint Booth
1	Electric furnace with central air	1	Front office
1	Bulk stack air handling unit	3	Compound
1	Rig stack air handling unit	3	Compound
2	Rig and Bulk stack air handling units pitot tubes	3	Compound
1	Gas furnace with central air	1	Milling / molding

APPENDIX D

Radiological Occupational Annual Dose Data for 2018

SRBT RADIOLOGICAL DOSE DATA (2014 - 2018)



(Note: QCD = Quarterly Collective Dose)

APPENDIX D

SRBT ROLLING FIVE-YEAR EFFECTIVE DOSE DATA (2014 - 2018)

ANNUAL DOSE (mSv)	2014	2015	2016	2017	2018	AVERAGE
Maximum Dose	1.29 mSv	0.87	0.34	0.46	0.48	**0.69**
Average Dose	0.10	0.07	0.049	0.045	0.044	**0.062**
Collective Dose	4.98	3.22	2.21	1.96	2.06	**2.89**

EFFECTIVE DOSE RANGE (mSv)	2014	2015	2016	2017	2018	AVERAGE
0 – 0.05	32 workers	33	32	36	39	**34**
0.05 – 0.10	7	5	7	4	1	**5**
0.10 – 0.25	5	5	3	2	5	**4**
0.25 – 0.50	0	3	3	3	2	**2**
0.50 – 1.00	3	1	0	0	0	**1**
>1.00	1	0	0	0	0	**0**
Number of Workers Monitored	48	47	45	45	47	**46**

APPENDIX E

Swipe Monitoring Results for 2018

2018 Routine Contamination Assessment Summary - Zone 3

Zone 3 Swipe Area	No. of Assessments	Amount > Admin. Level	Pass Rate
Rig 7 Floor	241	13	94.6
Rig 7	241	8	96.7
Rig 1 Floor	241	11	95.4
Rig 1	241	2	99.2
Flr @ Rig 6	241	14	94.2
Rig 6	241	3	98.8
Floor @ Rig 8	241	8	96.7
Rig 8	241	0	100.0
Floor @ Rig 5	241	34	85.9
Rig 5	241	4	98.3
Flr @ Barrier	241	18	92.5
Laser rm flr random	241	22	90.9
EIP Area	241	19	92.1
Laser Rm F/H	241	26	89.2
Trit Lab Flr random	241	12	95.0
Shoe Covers	241	27	88.8
Muffle F/H	241	18	92.5
Disass. Fume Hood	239	14	94.1
Scint Table	123	1	99.2
Reclaim F/H	122	0	100.0
Bulk Splitter Fume Hood	119	2	98.3
Variac	116	7	94.0
Lower Reclaim Cabinets	63	0	100.0
Waste Room Racks	62	3	95.2
Waste Room Floor	62	2	96.8
Shoe Cover Bins	62	2	96.8
Trit Lab Desk	62	2	96.8
Bulk Splitter Sash	62	2	96.8
Laser Stock Cabinet	61	1	98.4
Laser Room Microscope	61	2	96.7
Waste Room Door	60	0	100.0
Cabinets Beneath Disassy	60	3	95.0
Lower B/S Cabinet	60	0	100.0
Metal Rig Table	60	3	95.0
Waste Room Shelving	56	5	91.1
Liquid Nitrogen Tank	56	0	100.0
Oven	56	4	92.9
Reclaim Sash	56	2	96.4
Port-Hole	2	0	100.0
Waste Room Walls	2	0	100.0
Cleaning Cabinet	2	0	100.0
Operations Logbook	2	0	100.0
Torch Handles	2	0	100.0
TOTAL ZONE 3	**5785**	**294**	**94.9**

2018 Routine Contamination Assessment Summary - Zone 2

Zone 2 Swipe Area	No. of Assessments	Amount > Admin. Level	Pass Rate
Floor at Barrier	144	13	91.0
Work Area Floors	144	11	92.4
Work Counters	144	3	97.9
Shoe Covers	144	13	91.0
Insp. Prep. Counter	144	6	95.8
Microscope	110	6	94.5
Photometer Room Floor	107	6	94.4
Inspection Prep Floor	107	12	88.8
Floor Beside Disassambly	107	14	86.9
Silk Screening Room	75	5	93.3
WIP Cabinets	73	6	91.8
Laser Light Trays	69	6	91.3
Wire Rack at Barrier	44	2	95.5
Racks in Spray Room	37	0	100.0
Stock Cabinets	36	1	97.2
UV Printing Room	36	2	94.4
Sign Light Stock Cabinet	36	3	91.7
WIP Rack	36	0	100.0
Insp. Dark Room Counter	36	0	100.0
Disassembly Bins	33	6	81.8
Paint Booth	33	0	100.0
Counter at Barrier	30	2	93.3
Welding Area	1	0	100.0
Exposing Unit	1	0	100.0
UV Printing Room	1	0	100.0
TOTAL ZONE 2	**1728**	**117**	**93.2**

2018 Routine Contamination Assessment Summary - Zone 1

Zone 1 Swipe Area	No. of Assessments	Amount > Admin. Level	Pass Rate
Lunch Room	50	1	98.0
LSC Room	50	1	98.0
RR Ante Rm	50	2	96.0
RR Barrier	50	3	94.0
Assy Barrier	50	3	94.0
Disassembly Wire Racks	50	1	98.0
Shipping Area	50	0	100.0
Shipping Computer Area	13	0	100.0
Shane's Office	13	0	100.0
Peter's Office	13	0	100.0
Wire Cart	13	0	100.0
Shipping Shelving	13	0	100.0
Floor in Machine Shop	13	0	100.0
Doorknobs	13	0	100.0
Punchcard Area	13	0	100.0
LSC Garbage Cans	13	0	100.0
Disassembly Table	11	3	72.7
Mold Storage	11	0	100.0
RMA Storage Area	11	1	90.9
TOTAL ZONE 1	**500**	**15**	**97.0**

Overall Facility Summary

Facility Zone	No. of Assessments	Amount > Admin. Level	Pass Rate
ZONE 3	5,785	294	94.9
ZONE 2	1,728	117	93.2
ZONE 1	500	15	97.0
TOTAL ZONE 1	**8,013**	**426**	**94.7**

APPENDIX F

Passive Air Sampler Results for 2018

2018 Environment Monitoring Program
Passive Air Sampling System

Sampler No.	Sampler ID	Location	Dist. to SRBT	Jan (Bq/m3)	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average (Bq/m3)
				Jan 3 - Feb 1	Feb 1 - Mar 1	Mar 1 - Apr 4	Apr 4 - May 3	May 3 - Jun 1	Jun 1 - Jun 29	Jun 29 - Aug 1	Aug 1 - Sep 4	Sep 4 - Oct 1	Oct 1 - Nov 1	Nov 1 - Dec 3	Dec 3 - Jan 3	
1	N250	N 45º 48.486' W 077º 07.092' Elev. 137m	322m	1.10	0.33	0.26	1.50	1.20	1.30	2.60	2.60	1.60	0.80	0.33	0.34	1.16
2	N500	N 45º 48.572' W 077º 07.008' Elev. 134m	493m	0.73	0.33	0.26	0.31	0.30	0.52	0.79	0.84	0.84	0.52	0.33	0.34	0.51
3	N1000	N 45º 48.869' W 077º 06.997' Elev. 135m	1040m	0.31	0.33	0.26	0.30	0.31	0.31	0.27	0.42	0.34	0.34	0.33	0.34	0.32
4 (PAS #4)	NW250	N 45º 48.412' W 077º 07.189' Elev. 137m	222m	1.50	0.33	1.30	2.20	5.70	3.90	3.40	2.70	3.40	1.60	2.30	1.20	2.46
5	NW500	N 45º 48.577' W 077º 07.382' Elev. 134m	615m	1.00	0.33	0.32	0.35	1.20	0.76	0.83	0.66	1.20	0.58	0.90	0.59	0.73
6 (PAS # 8)	NW1000	N 45º 48.754' W 077º 07.599' Elev. 130m	1050m	0.60	0.33	0.26	0.31	0.57	0.45	0.62	0.27	0.50	0.34	0.33	0.42	0.42
7	NW2000	N 45º 49.141' W 077º 08.090' Elev. 139m	2000m	0.31	0.33	0.26	0.32	0.32	0.33	0.28	0.28	0.35	0.34	0.33	0.34	0.32
8	W250	N 45º 48.300' W 077º 07.323' Elev. 138m	297m	0.58	0.91	1.00	0.95	2.30	1.10	0.50	0.50	2.30	1.00	1.20	0.80	1.10
9	W500	N 45º 48.288' W 077º 07.393' Elev. 137m	389m	0.39	0.42	0.49	0.58	1.30	0.52	0.33	0.27	1.60	0.52	0.78	0.45	0.64
10	W1000	N 45º 48.306' W 077º 07.630' Elev. 134m	691m	0.39	0.37	0.30	0.33	0.69	0.31	0.26	0.26	0.69	0.33	0.52	0.34	0.40
11	SW250	N 45º 48.247' W 077º 07.206' Elev. 140m	183m	0.31	0.33	0.82	0.97	0.67	0.70	0.42	0.28	0.93	1.70	0.88	0.34	0.70
12	SW500	N 45º 47.896' W 077º 07.307' Elev. 148m	839m	0.31	0.33	0.26	0.31	0.30	0.31	0.26	0.27	0.34	0.34	0.33	0.34	0.31
13	SW1000	N 45º 47.599' W 077º 07.543' Elev. 149m	1470m	0.31	0.33	0.26	0.31	0.30	0.31	0.27	0.27	0.34	0.33	0.33	0.34	0.31
14	SW2000	N 45º 47.408' W 077º 07.866' Elev. 155m	2110m	0.31	0.33	0.26	0.31	0.31	0.31	0.27	0.27	0.34	0.34	0.33	0.33	0.31
15	S250	N 45º 48.129' W 077º 07.014' Elev. 131m	356m	0.37	0.34	1.00	0.99	0.59	2.00	0.80	0.90	1.40	1.10	0.40	0.39	0.86
16	S500	N 45º 48.029' W 077º 07.110' Elev. 143m	532m	0.31	0.33	0.28	0.31	0.30	0.58	0.27	0.42	0.34	0.34	0.33	0.34	0.35
17 (PAS # 12)	S1000	N 45º 46.466' W 077º 07.441' Elev. 158m	1450m	0.31	0.33	0.26	0.30	0.30	0.31	0.27	0.27	0.34	0.33	0.33	0.34	0.31
18	SE250	N 45º 48.189' W 077º 06.874' Elev. 132m	365m	3.30	1.80	3.30	3.60	1.30	3.80	1.10	2.50	1.90	1.80	5.00	2.30	2.64
19	SE500	N 45º 48.108' W 077º 06.783' Elev. 123m	554m	1.60	0.73	1.60	1.70	0.70	1.90	0.70	1.10	1.00	0.90	2.00	0.60	1.21
20	SE1000	N 45º 47.894' W 077º 06.501' Elev. 120m	1090m	0.31	0.33	0.48	0.60	0.30	0.53	0.35	0.28	0.44	0.34	0.33	0.34	0.39
21	SE2000	N 45º 47.505' W 077º 05.978' Elev. 137m	2080m	0.31	0.34	0.26	0.31	0.30	0.31	0.26	0.26	0.34	0.34	0.33	0.34	0.31
22	E250	N 45º 48.234' W 077º 06.807' Elev. 131m	401m	1.90	1.10	1.80	2.20	0.30	1.80	1.00	1.80	2.30	1.40	3.60	*	1.75
23	E500	N 45º 48.333' W 077º 06.693' Elev. 132m	520m	0.31	0.33	0.26	0.69	0.30	1.26	0.76	1.17	0.91	0.45	0.91	0.34	0.64
24	E1000	N 45º 48.303' W 077º 06.260' Elev. 143m	1080m	0.31	0.33	0.26	0.31	0.30	0.28	0.35	0.45	0.34	0.34	0.51	0.34	0.34
25	NE250	N 45º 48.371' W 077º 06.964' Elev. 124m	198m	1.10	1.40	0.30	1.70	1.10	11.10	4.90	5.70	3.40	3.00	2.80	0.70	3.10
26	NE500	N 45º 48.421' W 077º 06.732' Elev. 131m	508m	0.32	0.40	0.26	0.75	0.30	1.30	0.80	1.00	1.20	0.60	0.70	0.34	0.66
27	NE1000	N 45º 48.683' W 077º 06.441' Elev. 148m	1100m	0.31	0.33	0.26	0.31	0.28	0.42	0.26	0.36	0.55	0.34	0.33	0.34	0.34
28	NE2000	N 45º 49.116' W 077º 05.843' Elev. 156m	2200m	0.31	0.33	0.26	0.31	0.30	0.30	0.27	0.27	0.33	0.33	0.33	0.33	0.31
Pre-Sample Points																
(PAS #1)		N 45º 48.287' W 077º 07.123' Elev. 129m	94.1m	0.59	0.42	3.70	2.20	4.20	11.70	4.10	12.30	7.30	4.20	1.70	2.60	4.58
(PAS #2)		N 45º 48.325' W 077º 07.132' Elev. 132m	52.8m	2.00	0.67	2.50	4.50	8.20	6.30	6.70	4.30	10.30	1.80	2.90	1.80	4.33
(PAS #13)		N 45º 48.262' W 077º 07.093' Elev. 132m	61.5m	0.31	0.38	2.00	2.40	3.90	7.90	2.80	6.00	5.00	4.20	2.10	1.90	3.24
Replicates																
4-2	NW250	N 45º 48.412' W 077º 07.189' Elev. 137m	222m	1.40	0.30	1.20	2.10	5.70	3.80	3.30	2.60	3.30	1.30	2.10	1.20	2.36
11-2	SW250	N 45º 48.247' W 077º 07.206' Elev. 140m	183m	0.31	0.33	0.79	0.70	0.63	0.52	0.41	0.27	0.82	1.70	0.81	0.33	0.64
18-2	SE250	N 45º 48.189' W 077º 06.874' Elev. 132m	365m	2.90	1.50	3.10	3.30	1.00	3.30	1.00	2.30	1.80	1.80	4.10	1.90	2.33
25-2	NE250	N 45º 48.371' W 077º 06.964' Elev. 124m	198m	1.00	1.10	0.30	1.50	1.00	6.60	4.30	4.90	3.00	2.40	2.50	0.50	2.43
Background Samples																
Maika (PAS # 10)	SW	N 45º 46.367' W 077º 11.447' Elev. 149m	6690m	0.31	0.34	0.26	0.31	0.31	0.31	0.28	0.27	0.34	0.34	0.33	0.34	0.31
Maika	Duplicate	Same as above	6690m	0.31	0.33	0.26	0.31	0.30	0.31	0.27	0.27	0.34	0.34	0.33	0.34	0.31
Fitzpatrick	SE	N 45° 44.818' W 076° 59.822' Elev. 159m	11400m	0.31	0.34	0.26	0.31	0.36	0.42	1.30	0.40	0.35	0.30	0.33	0.34	0.42
Petawawa	NW	N 45° 51.497' W 077° 12.828' Elev. 149m	9480m	0.31	0.33	0.26	0.31	0.30	0.31	0.27	0.27	0.34	0.34	0.33	0.34	0.31
Farm	NE	N 45° 53.071' W 076° 56.768' Elev. 142m	16000m	0.31	0.33	0.26	0.31	0.31	0.31	0.27	0.27	0.34	0.34	0.34	0.34	0.31
Results shaded in blue are below minimum detectable activity			Sum	29.28	20.12	31.78	41.38	48.35	78.80	48.19	60.52	62.79	39.75	44.99	25.48	44.43

* No Sample Available

APPENDIX G

Wind Direction Graphs for 2018

2018 Passive Air Sampling Data (Results in Bq/m^3)

Passive Air Sampling Data (Results in Bq/m3)

1st Quarter

Direction	January 250 M	January 500 M	January 1000 M	January 2000 M	February 250 M	February 500 M	February 1000 M	February 2000 M	March 250 M	March 500 M	March 1000 M	March 2000 M
North	1.10	0.73	0.31		0.33	0.33	0.33		0.26	0.26	0.26	
North West	1.50	1.00	0.60	0.31	0.33	0.33	0.33	0.33	1.30	0.32	0.26	0.26
West	0.58	0.39	0.39		0.91	0.42	0.37		1.00	0.49	0.30	
Southwest	0.31	0.31	0.31	0.31	0.33	0.33	0.33	0.33	0.82	0.26	0.26	0.26
South	0.37	0.31	0.31		0.34	0.33	0.33		1.00	0.28	0.26	
South East	3.30	1.60	0.31	0.31	1.80	0.73	0.33	0.34	3.30	1.60	0.48	0.26
East	1.90	0.31	0.31		1.10	0.33	0.33		1.80	0.26	0.26	
North East	1.10	0.32	0.31	0.31	1.40	0.40	0.33	0.33	0.30	0.26	0.26	0.26

2nd Quarter

Direction	April 250 M	April 500 M	April 1000 M	April 2000 M	May 250 M	May 500 M	May 1000 M	May 2000 M	June 250 M	June 500 M	June 1000 M	June 2000 M
North	1.50	0.31	0.30		1.20	0.30	0.31		1.30	0.52	0.31	
North West	2.20	0.35	0.31	0.32	5.70	1.20	0.57	0.32	3.90	0.76	0.45	0.33
West	0.95	0.58	0.33		2.30	1.30	0.69		1.10	0.52	0.31	
Southwest	0.97	0.31	0.31	0.31	0.67	0.30	0.30	0.31	0.70	0.31	0.31	0.31
South	0.99	0.31	0.30		0.59	0.59	0.30		2.00	0.58	0.31	
South East	3.60	1.70	0.60	0.31	1.30	0.70	0.30	0.30	3.80	1.90	0.53	0.31
East	2.20	0.69	0.31		0.30	0.30	0.30		1.80	1.26	0.28	
North East	1.70	0.75	0.31	0.31	1.10	0.30	0.28	0.30	11.10	1.30	0.42	0.30

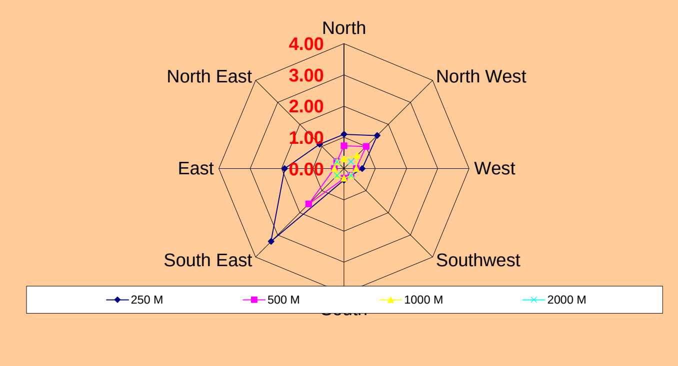
3rd Quarter

Direction	July 250 M	July 500 M	July 1000 M	July 2000 M	August 250 M	August 500 M	August 1000 M	August 2000 M	September 250 M	September 500 M	September 1000 M	September 2000 M
North	2.60	0.79	0.27		2.60	0.84	0.42		1.60	0.84	0.34	
North West	3.40	0.83	0.62	0.28	2.70	0.66	0.27	0.28	3.40	1.20	0.50	0.35
West	0.50	0.33	0.26		0.50	0.27	0.26		2.30	1.60	0.69	
Southwest	0.42	0.26	0.27	0.27	0.28	0.27	0.27	0.27	0.93	0.34	0.34	0.34
South	0.80	0.27	0.27		0.90	0.42	0.27		1.40	0.34	0.34	
South East	1.10	0.70	0.35	0.26	2.50	1.10	0.28	0.26	1.90	1.00	0.44	0.34
East	1.00	0.76	0.35		1.80	1.17	0.45		2.30	0.91	0.34	
North East	4.90	0.80	0.26	0.27	5.70	1.00	0.36	0.27	3.40	1.20	0.55	0.33

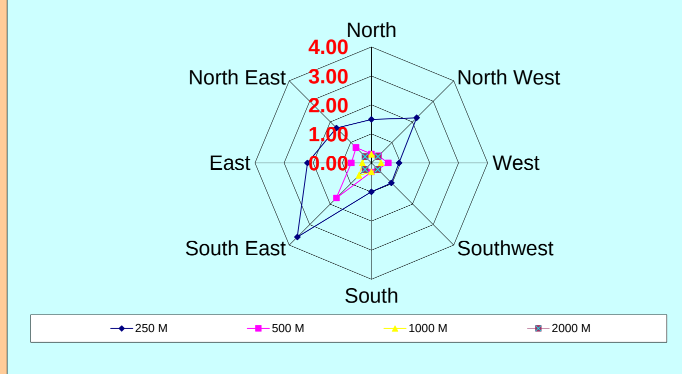
4th Quarter

Direction	October 250 M	October 500 M	October 1000 M	October 2000 M	November 250 M	November 500 M	November 1000 M	November 2000 M	December 250 M	December 500 M	December 1000 M	December 2000 M
North	0.80	0.52	0.34		0.33	0.33	0.33		0.34	0.34	0.34	
North West	1.60	0.58	0.34	0.34	2.30	0.90	0.33	0.33	1.20	0.59	0.42	0.34
West	1.00	0.52	0.33		1.20	0.78	0.52		0.80	0.45	0.34	
Southwest	1.70	0.34	0.33	0.34	0.88	0.33	0.33	0.33	0.34	0.34	0.34	0.33
South	1.10	0.34	0.33		0.40	0.33	0.33		0.39	0.34	0.34	
South East	1.80	0.90	0.34	0.34	5.00	2.00	0.33	0.33	2.30	0.60	0.34	0.34
East	1.40	0.45	0.34		3.60	0.91	0.51		*	0.34	0.34	
North East	3.00	0.60	0.34	0.33	2.80	0.70	0.33	0.33	0.70	0.34	0.34	0.33

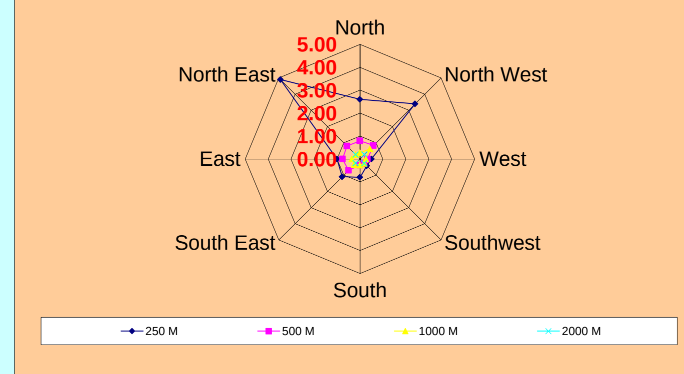
January
(Jan 3 - Feb 1)



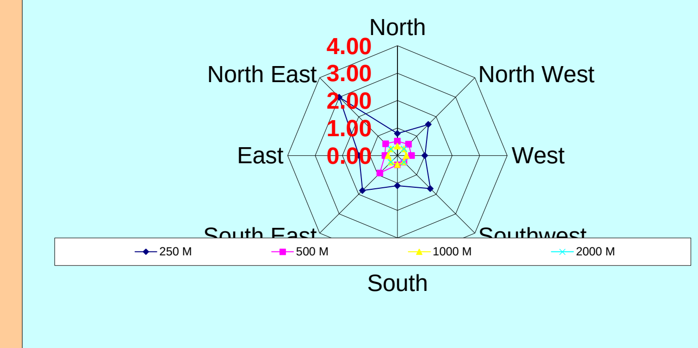
April
(Apr 4 - May 3)



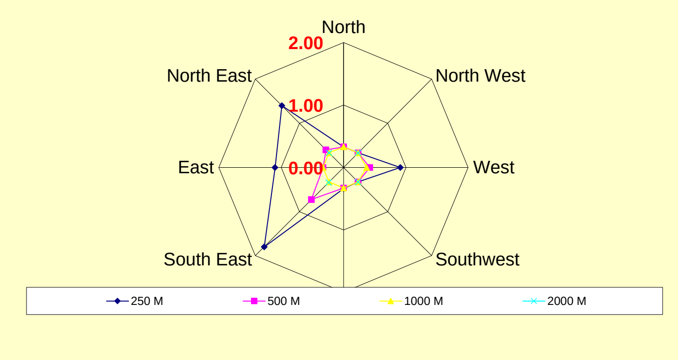
July
(Jun 29 - Aug 1)



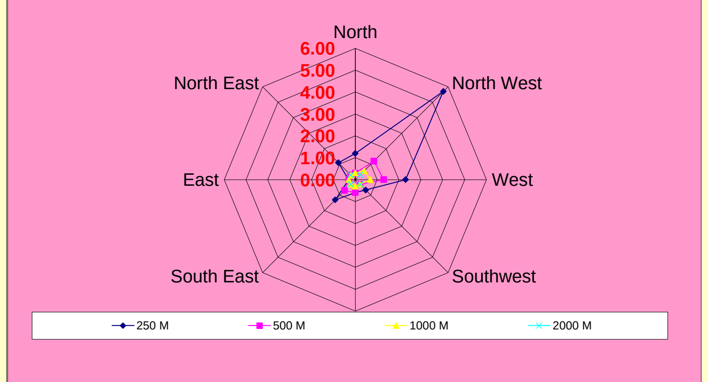
October
(Oct 1 - Nov 1)



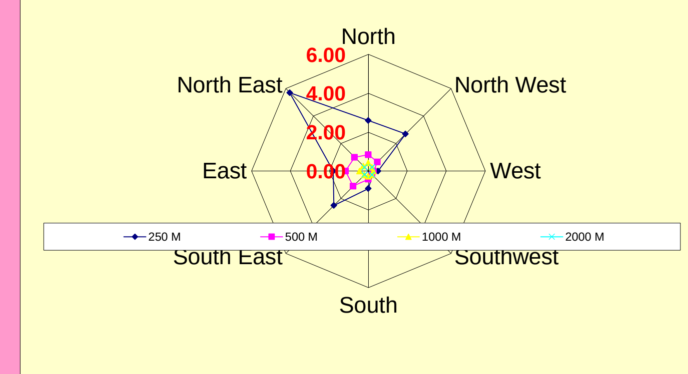
February
(Feb 1 - Mar 1)



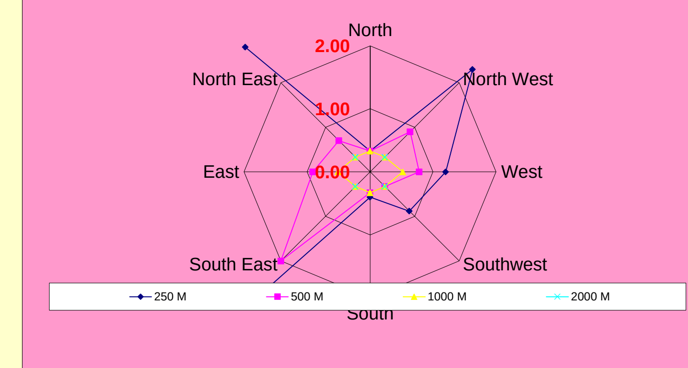
May
(May 3 - Jun 1)



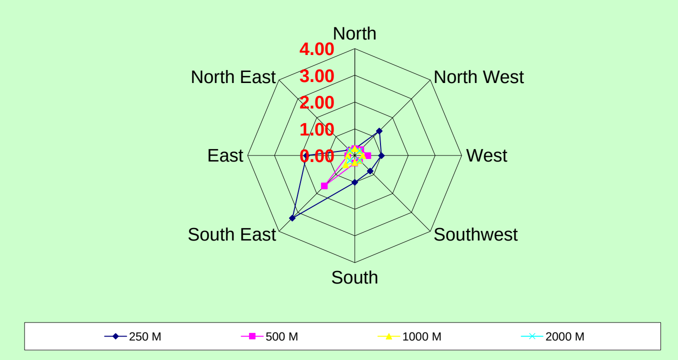
August
(Aug 1 - Sep 4)



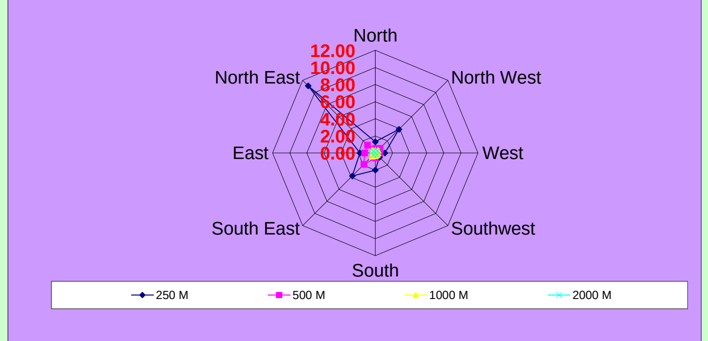
November
(Nov 1 - Dec 3)



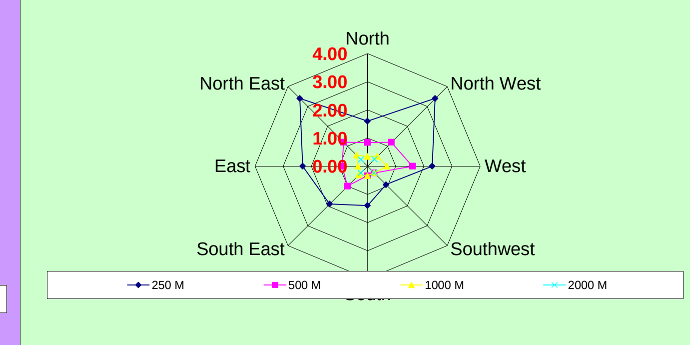
March
(Mar 1 - Apr 4)



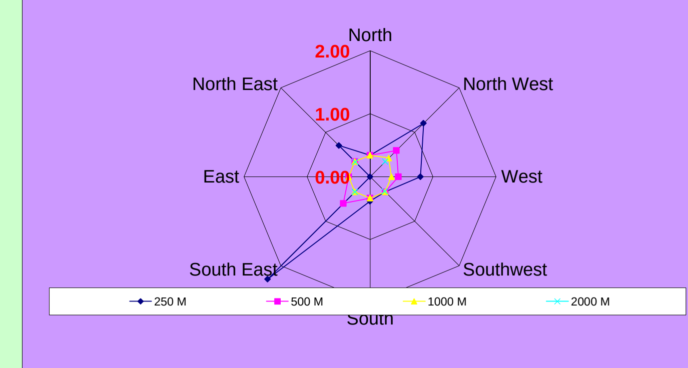
June
(Jun 1 - Jun 29)



September
(Sep 4 - Oct 1)



December
(Dec 3 - Jan 3)



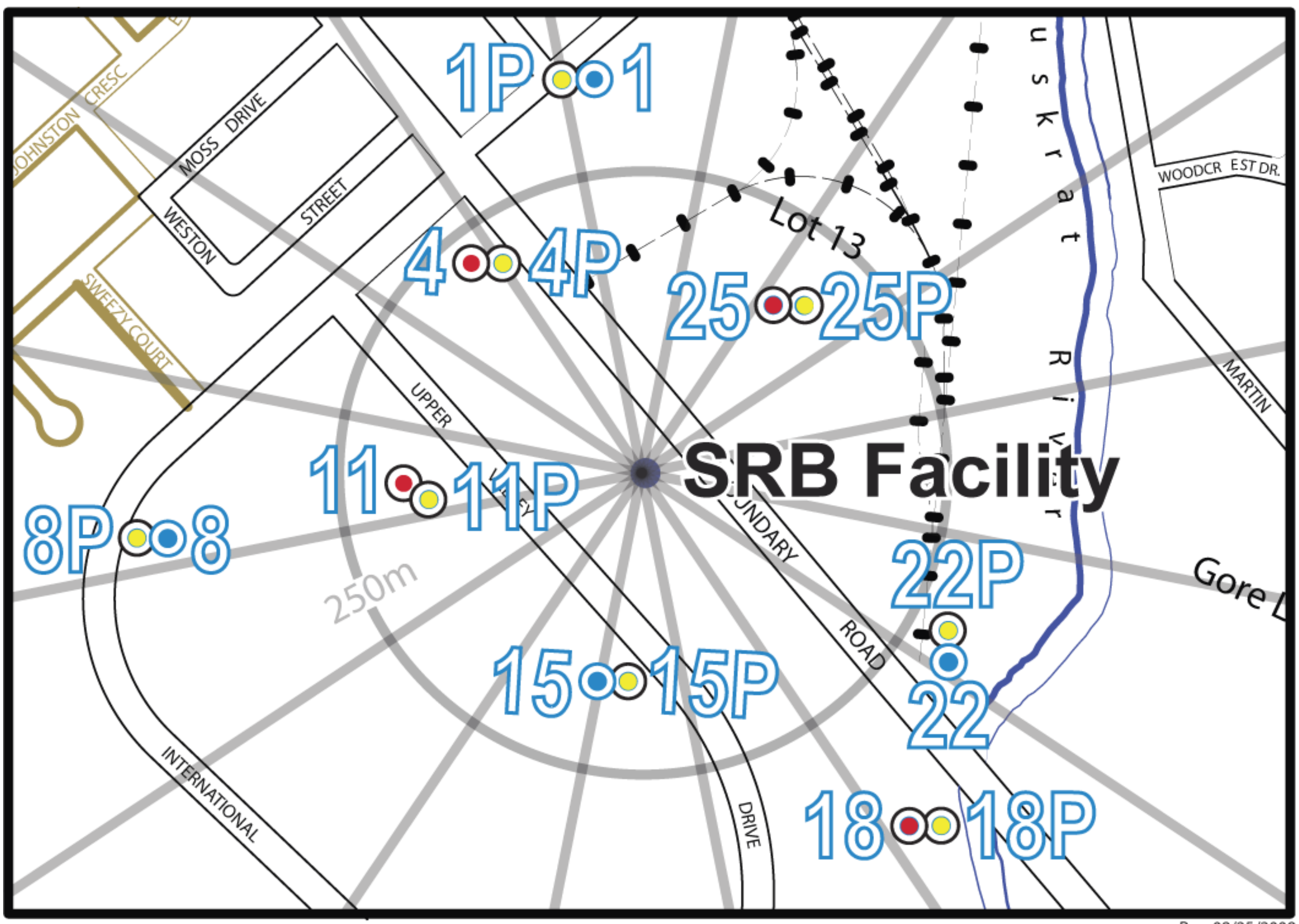
APPENDIX H

Precipitation Monitoring Results for 2018

PRECIPITATION SAMPLERS									
	1P	4P	8P	11P	15P	18P	22P	25P	AVG
Date Range	Bq/L								
January 3, 2018 - February 1, 2018	61	100	52	11	7	217	65	28	68
February 1, 2018 - March 1, 2018	10	24	93	35	29	48	58	61	45
March 1, 2018 - April 4, 2018	6	25	28	60	17	83	11	5	29
April 4, 2018 - May 3, 2018	5	11	83	No sample	16	40	32	113	43
May 3, 2018 - June 1, 2018	15	36	16	8	6	6	6	16	14
June 1, 2018 - June 29, 2018	5	79	7	5	6	18	6	39	21
June 29, 2018 - August 1, 2018	9	48	6	6	6		12	52	20
August 1, 2018 - September 4, 2018	8	16	6	20	5	6	6	15	10
September 4, 2018 - October 1, 2018	6	31	5	5	5	8	8	23	11
October 1, 2018 - November 1, 2018	51	24	10	10	5	191	23	10	41
November 1, 2018 - December 3, 2018	6	63	74	87	29	138	77	5	60
December 3, 2018 - January 4, 2019	12	24	24	17	77	130	No sample	34	45
AVERAGE	16	40	34	24	17	80	28	33	34

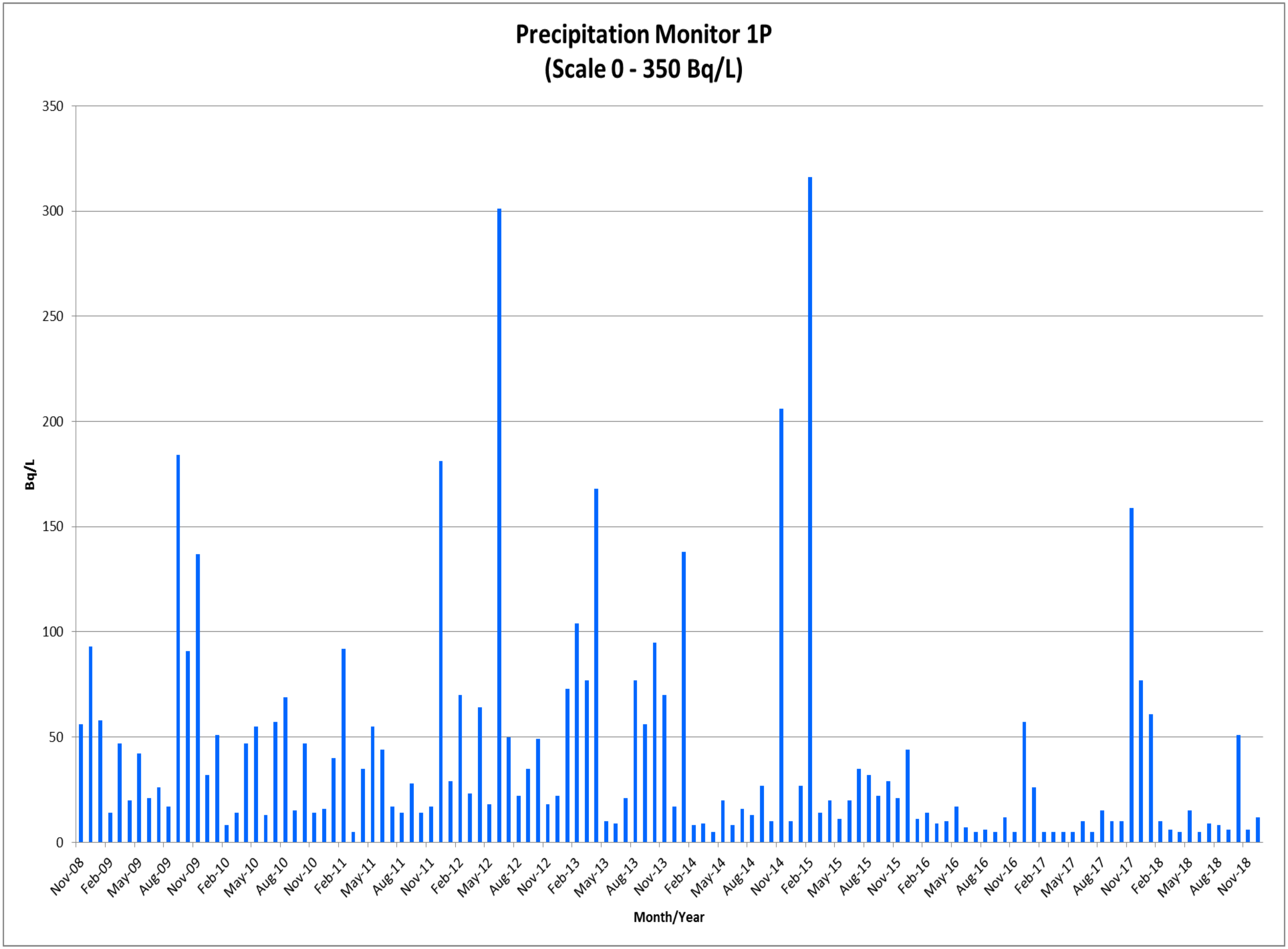
Results shaded in blue are <minimum detectable activity (MDA)

MAP OF AIR AND PRECIPITATION MONITORING STATIONS



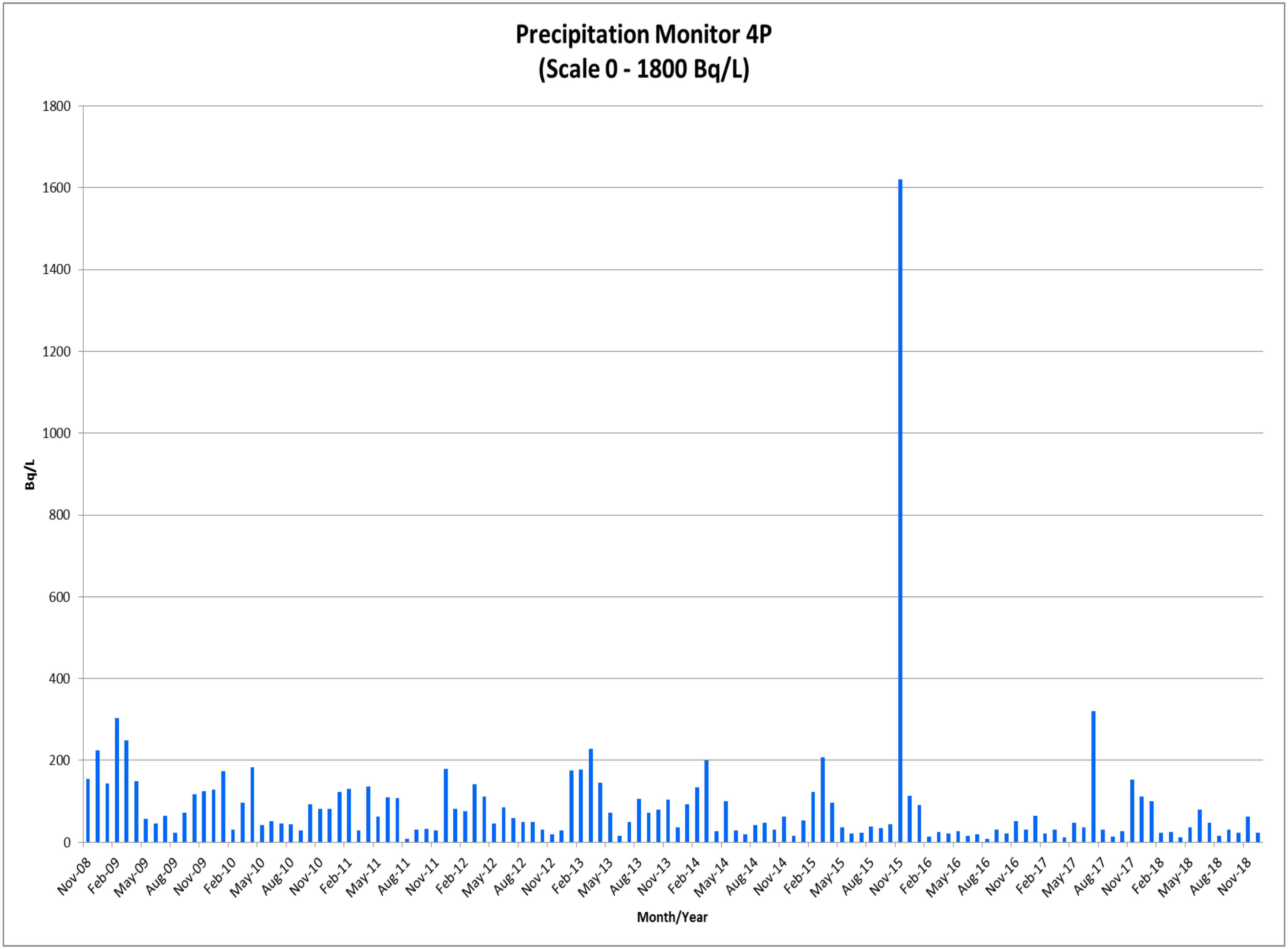
Rev. 08/25/2008

Air Monitoring Station   Air Monitoring Station With Duplicate   Precipitation Monitoring Station

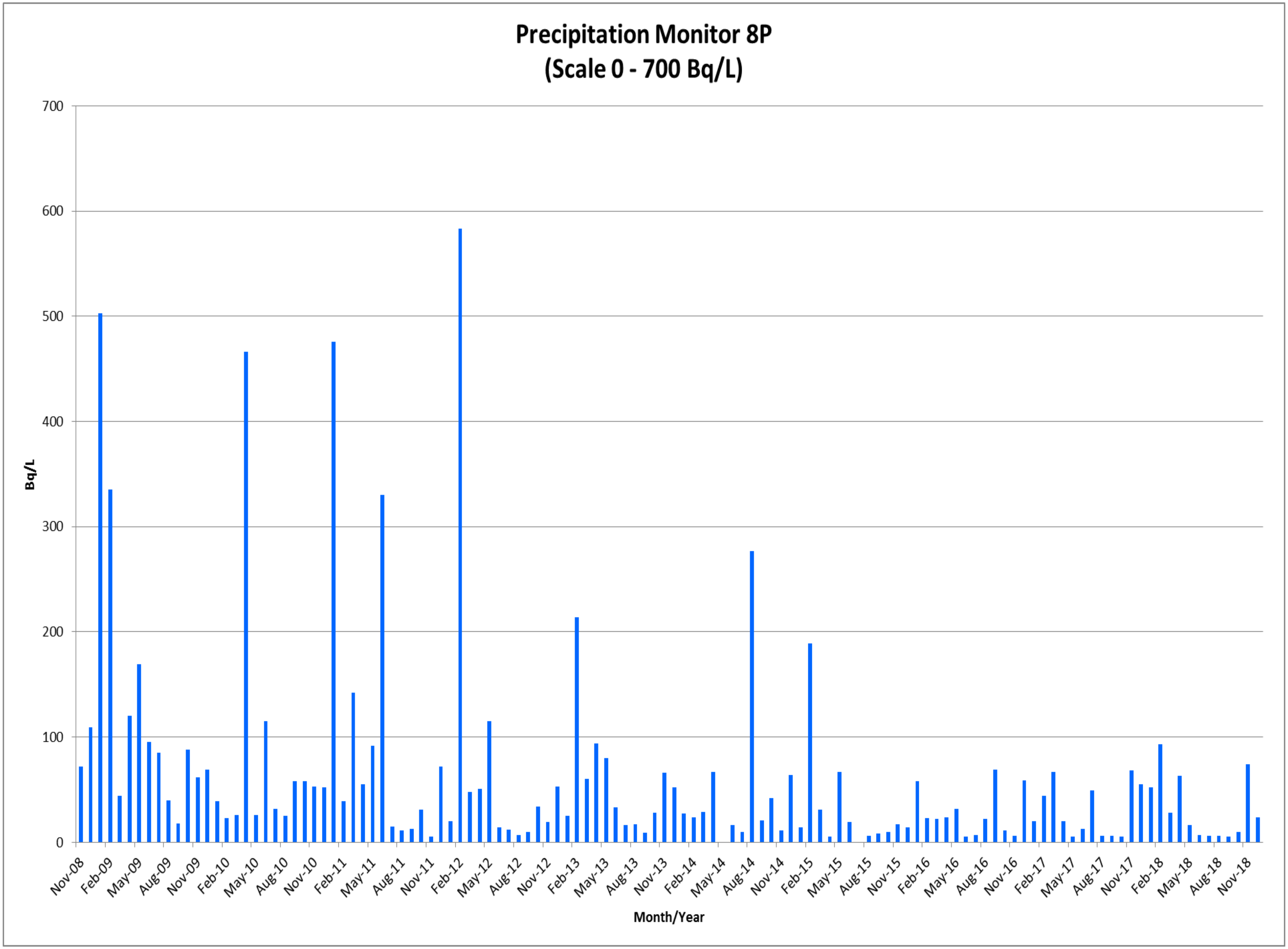


Precipitation Monitor 1P
(Scale 0 - 350 Bq/L)
350
300
250
200
150
100
50
0
Bq/L
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Month/Year

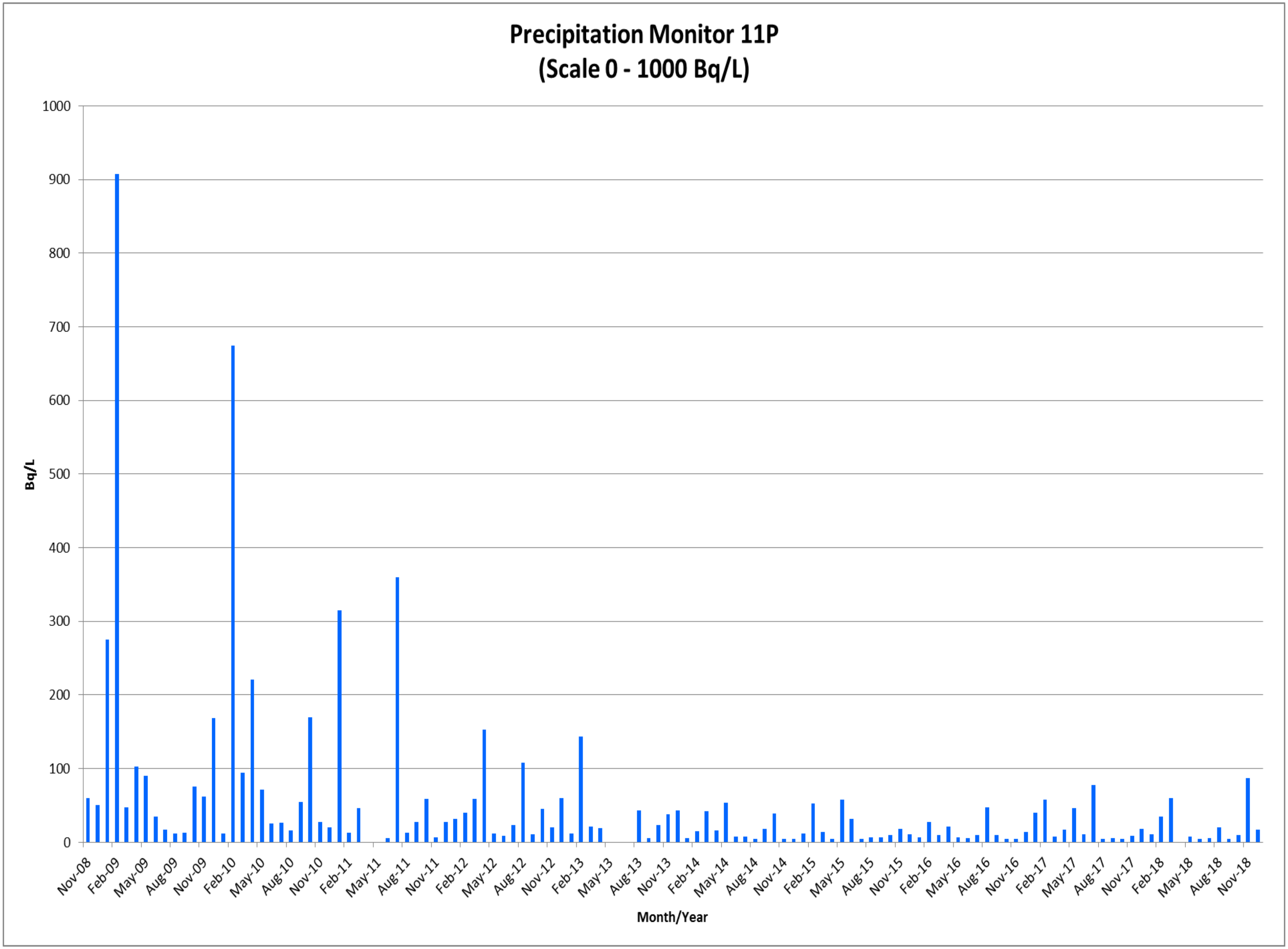
APPENDIX H


Precipitation Monitor 4P
(Scale 0 - 1800 Bq/L)
Bq/L
0
200
400
600
800
1000
1200
1400
1600
1800
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Month/Year

APPENDIX H

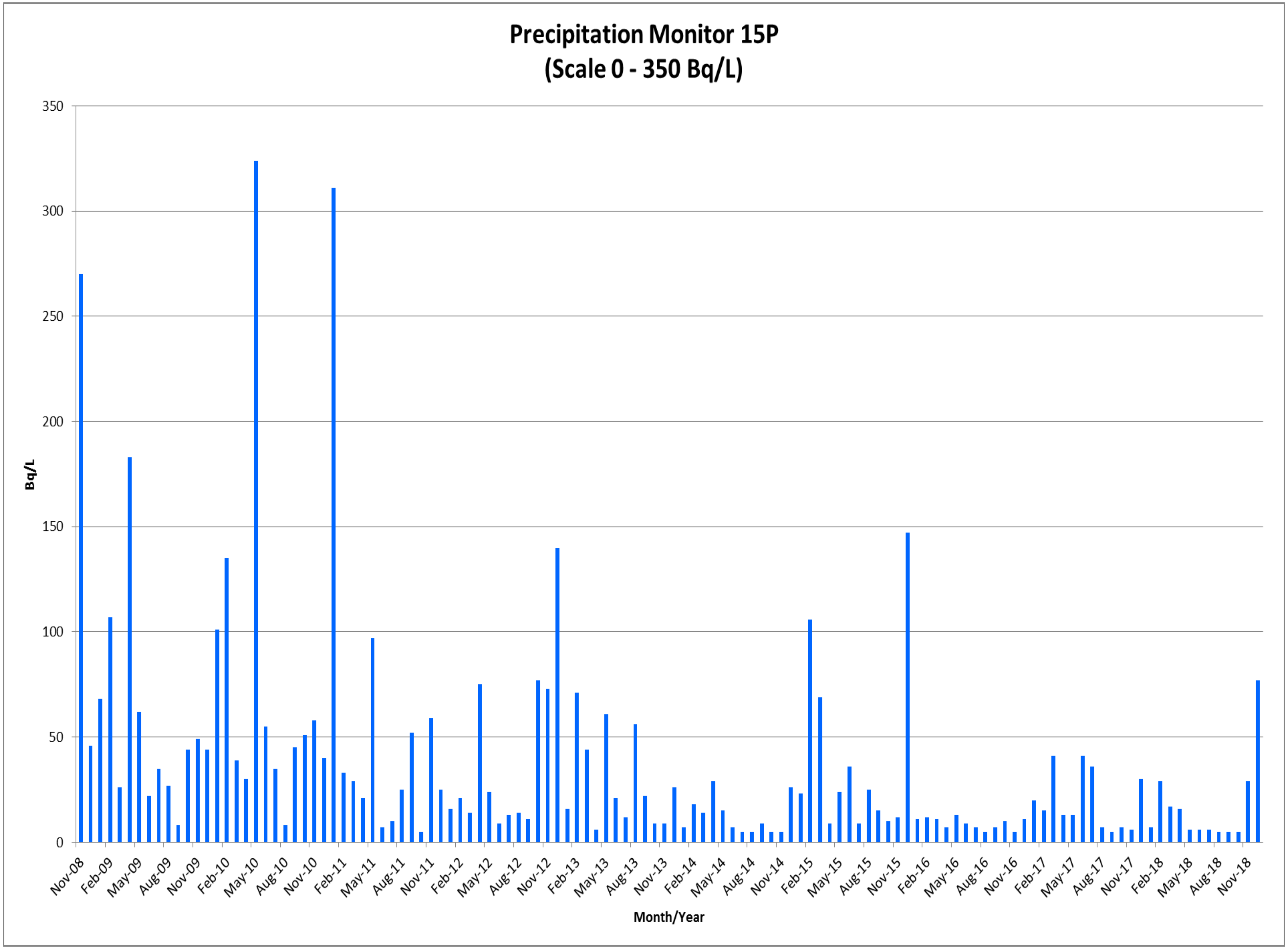

Precipitation Monitor 8P
(Scale 0 - 700 Bq/L)
Bq/L
700
600
500
400
300
200
100
0
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Month/Year

APPENDIX H

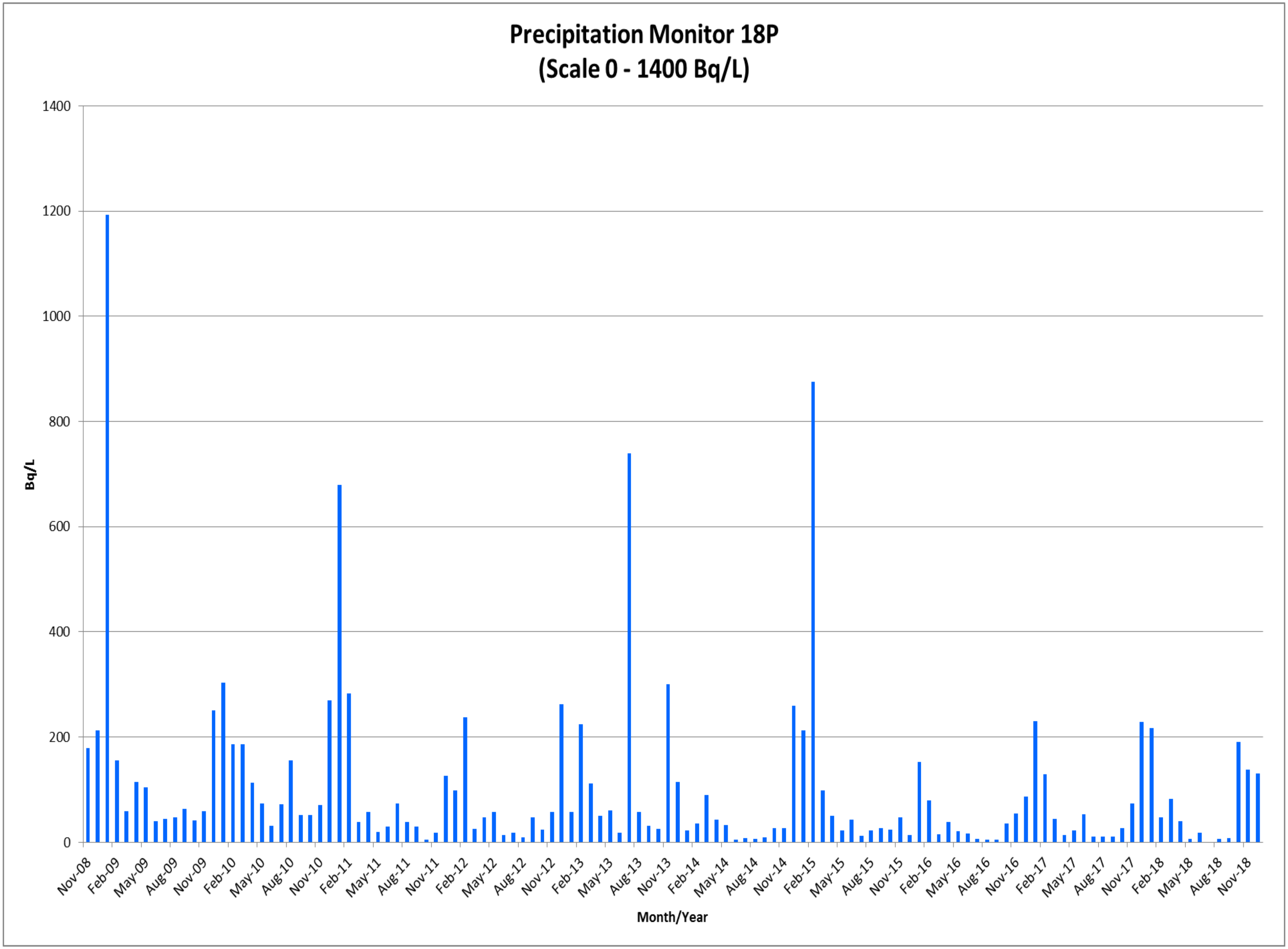


Precipitation Monitor 11P
(Scale 0 - 1000 Bq/L)
Bq/L
1000
900
800
700
600
500
400
300
200
100
0
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Month/Year

APPENDIX H

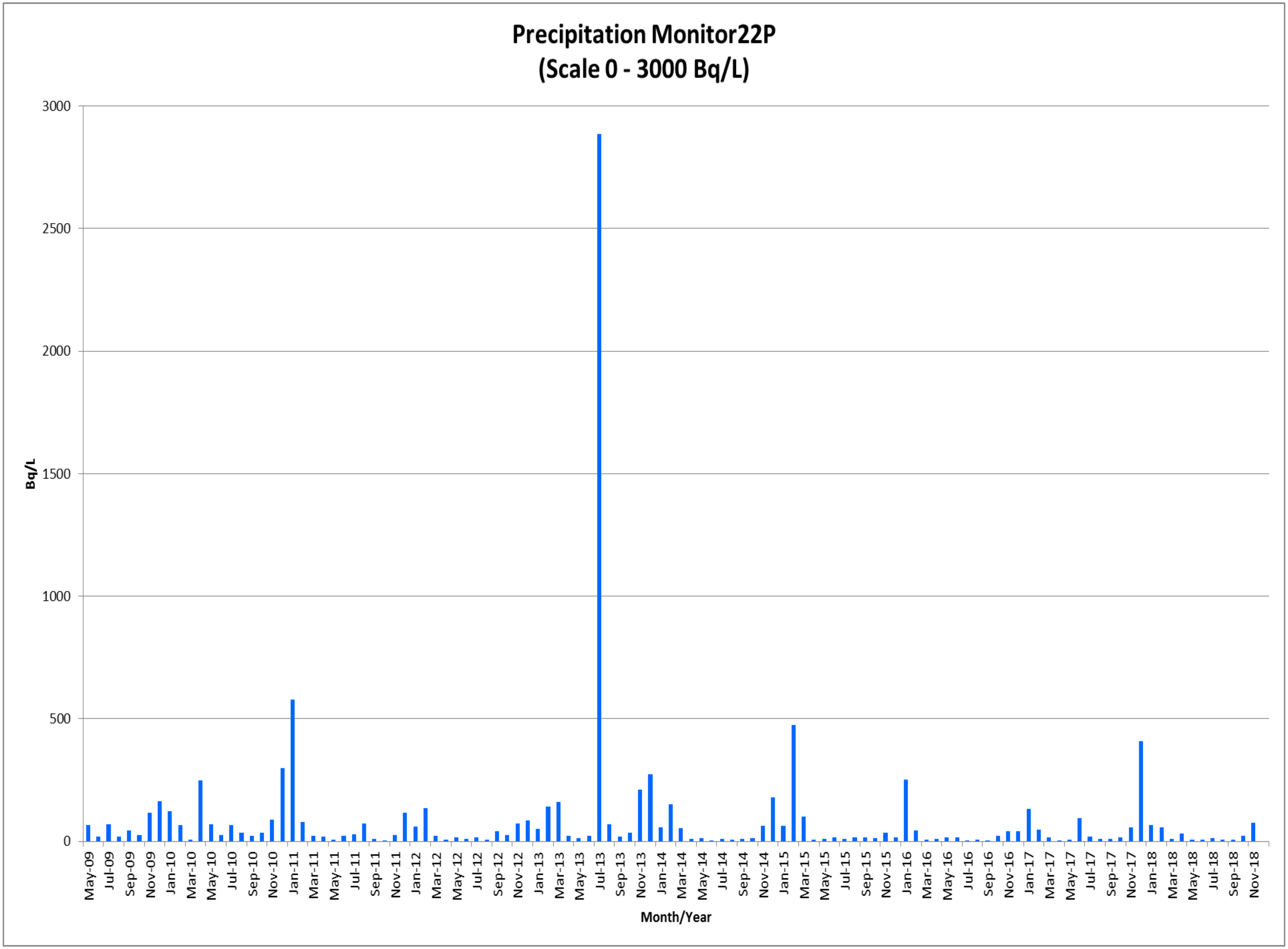


Precipitation Monitor 15P
(Scale 0 - 350 Bq/L)
Bq/L
Month/Year
350
300
250
200
150
100
50
0
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18

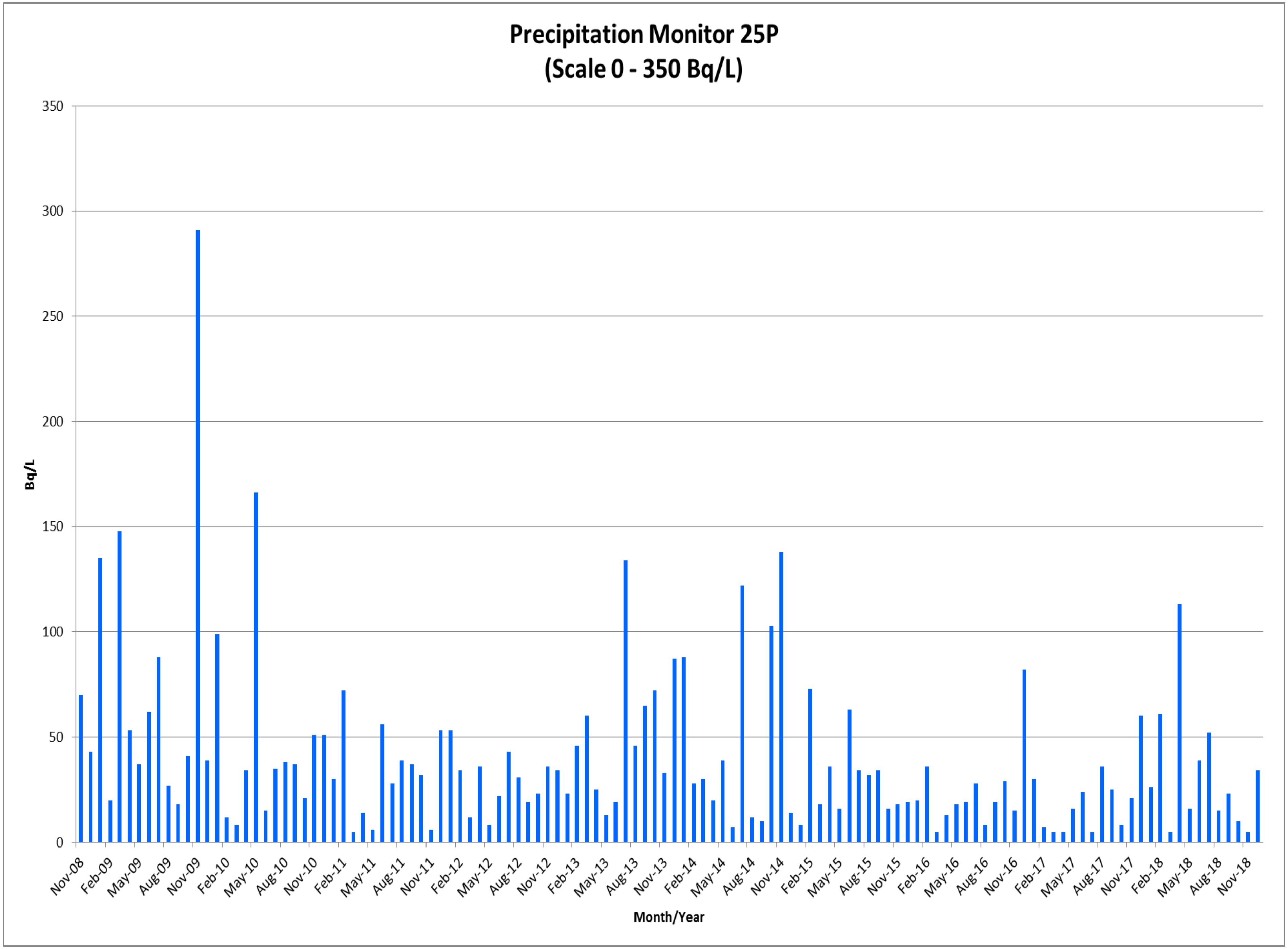


Precipitation Monitor 18P
(Scale 0 - 1400 Bq/L)
1400
1200
1000
800
600
400
200
0
Bq/L
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Month/Year

APPENDIX H


Precipitation Monitor22P
(Scale 0 - 3000 Bq/L)
Bq/L
3000
2500
2000
1500
1000
500
0
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Jan-11
Mar-11
May-11
Jul-11
Sep-11
Nov-11
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jul-14
Sep-14
Nov-14
Jan-15
Mar-15
May-15
Jul-15
Sep-15
Nov-15
Jan-16
Mar-16
May-16
Jul-16
Sep-16
Nov-16
Jan-17
Mar-17
May-17
Jul-17
Sep-17
Nov-17
Jan-18
Mar-18
May-18
Jul-18
Sep-18
Nov-18
Month/Year

APPENDIX H

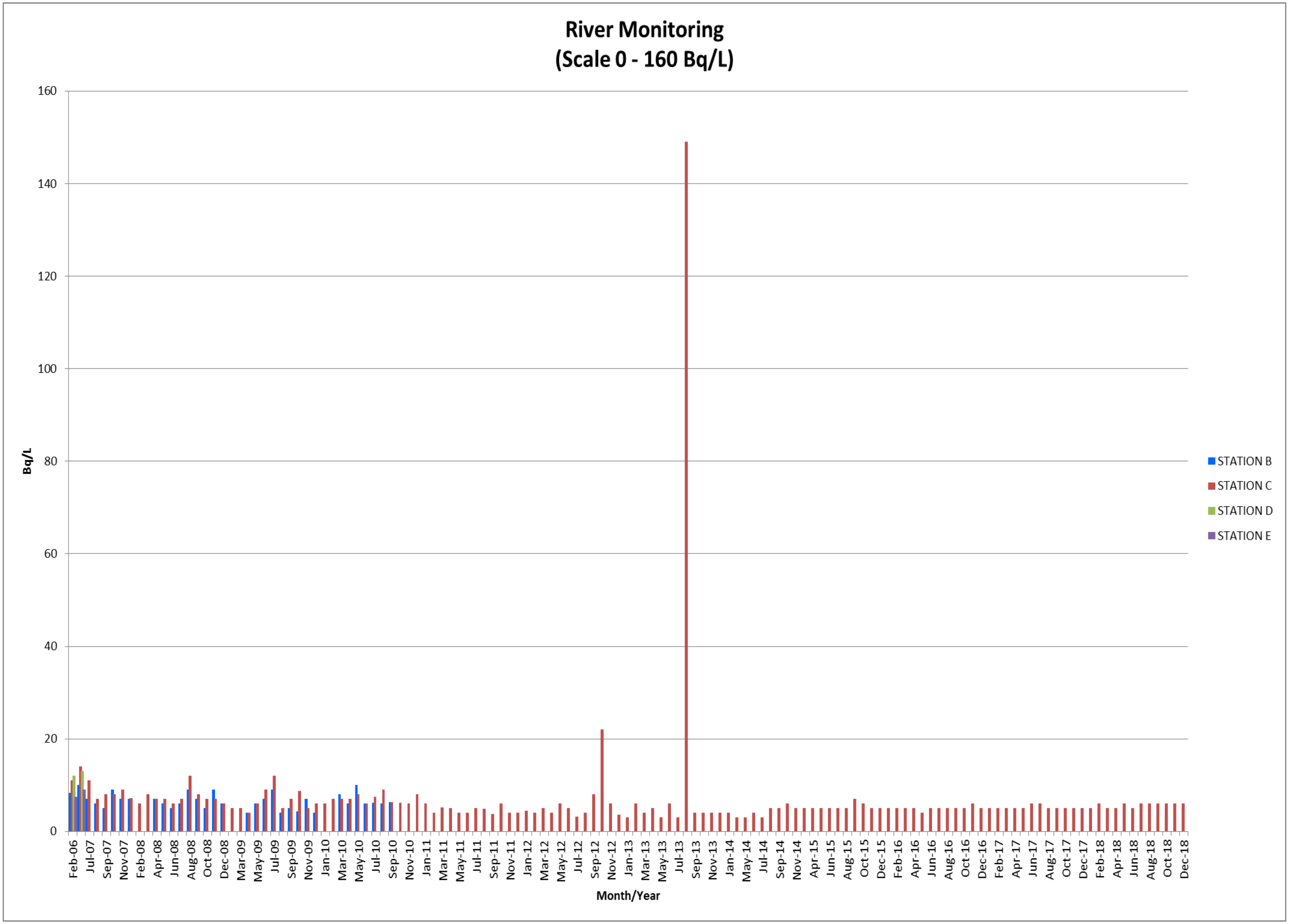


Precipitation Monitor 25P
(Scale 0 - 350 Bq/L)
350
300
250
200
150
100
50
0
Bq/L
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Month/Year

APPENDIX H

APPENDIX I

Receiving Waters Monitoring Results for 2018


River Monitoring
(Scale 0 - 160 Bq/L)
Bq/L
Month/Year
STATION B
STATION C
STATION D
STATION E
0
20
40
60
80
100
120
140
160
Feb-06
Jul-07
Sep-07
Nov-07
Feb-08
Apr-08
Jun-08
Aug-08
Oct-08
Dec-08
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Jan-11
Mar-11
May-11
Jul-11
Sep-11
Nov-11
Jan-12
Mar-12
May-12
Jul-12
Sep-12
Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
May-14
Jul-14
Sep-14
Nov-14
Apr-15
Jun-15
Aug-15
Oct-15
Dec-15
Feb-16
Apr-16
Jun-16
Aug-16
Oct-16
Dec-16
Feb-17
Apr-17
Jun-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Oct-18
Dec-18

APPENDIX I

RECEIVING WATERS MONITORING LOCATIONS

Basemap Source: City of Pembroke (www.pembrokeontario.com)

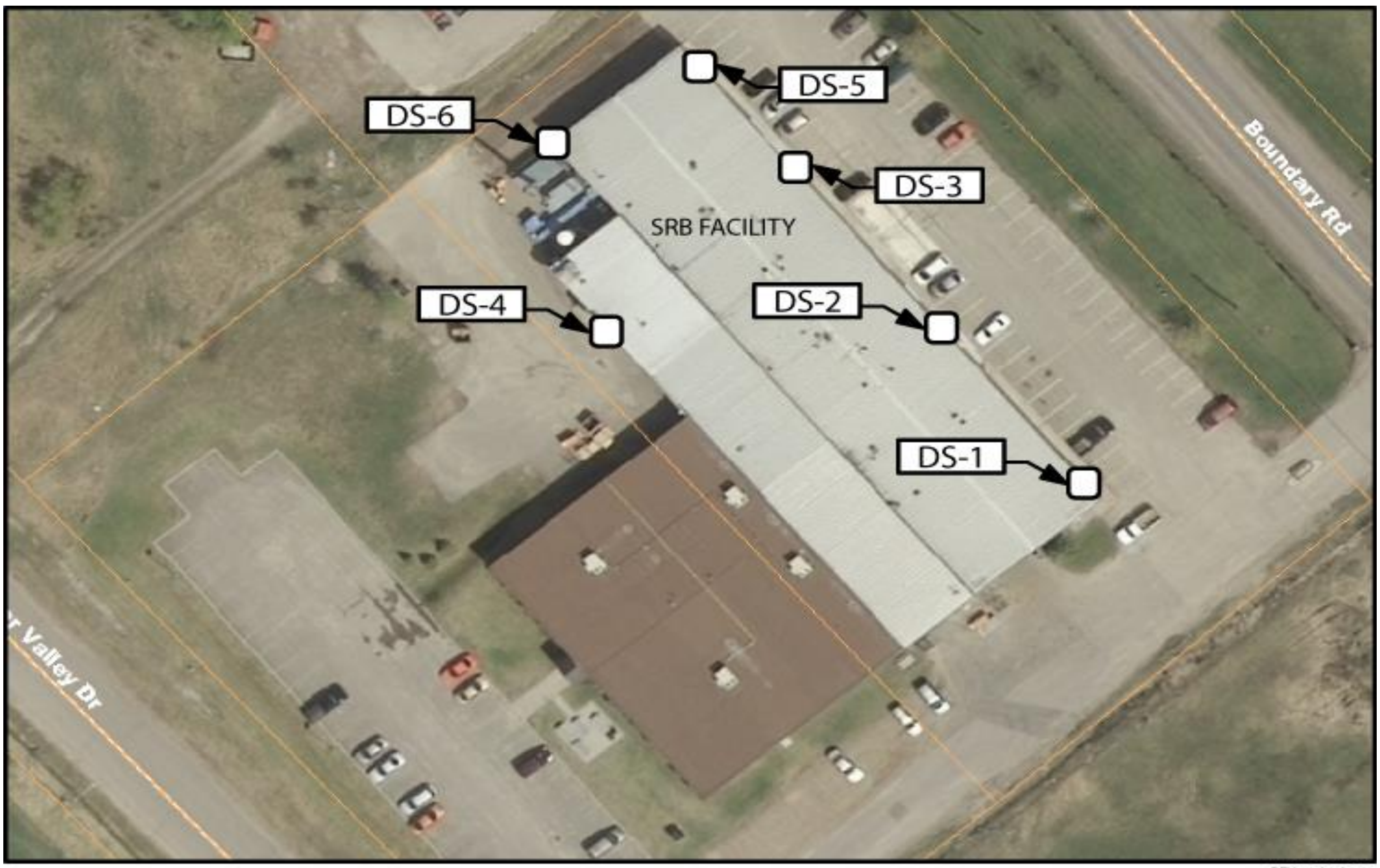
APPENDIX J

Runoff Monitoring Results for 2018

Facility Runoff Monitoring Results for 2018

DOWNSPOUTS (Bq/L)								
Date	**Time**	**DS-1**	**DS-2**	**DS-3**	**DS-4**	**DS-5**	**DS-6**	**MDA**
21-Feb-18	1:00 PM	No sample	493	313	317	244	258	56
13-Jun-18	4:30 PM	No sample	171	276	117	183	345	58
17-Aug-18	8:30 AM	126	92	103	85	143	190	45
31-Oct-18	10:00 AM	No sample	98	48	51	56	48	41
Average (Bq/L)		**126**	**214**	**185**	**143**	**157**	**210**	**50**
Average all results		**179 Bq/L**						

*MDA = Minimum Detectable Activity (measurements shaded in are <MDA)



LOCATION OF DOWNSPOUTS

REV. 03/25/2009

APPENDIX K

Produce Monitoring Results for 2018

Map – Residential Produce Sampling 2018

APPENDIX K

Map – Commercial Produce Sampling 2018

APPENDIX K

2018 Residential Produce Sampling – Free-water Tritium Concentration

Sample	Units	Result
Apples 406 Boundary Road	Bq/kg Fresh weight	85
Tomatoes 408 Boundary Road	Bq/kg Fresh weight	74
Onions 408 Boundary Road	Bq/kg Fresh weight	62
Cucumber 408 Boundary Road	Bq/kg Fresh weight	75
Apples 416 Boundary Road	Bq/kg Fresh weight	87
Apples 413 Sweezey Ct.	Bq/kg Fresh weight	91
Beet Tuber 413 Sweezey Ct.	Bq/kg Fresh weight	118
Cucumber 413 Sweezey Ct.	Bq/kg Fresh weight	105
Carrots 413 Sweezey Ct.	Bq/kg Fresh weight	91
Tomatoes 611 Moss Dr.	Bq/kg Fresh weight	72
Cucumber 611 Moss Dr.	Bq/kg Fresh weight	210

2018 Residential Produce Sampling – Organically-bound Tritium (OBT) Concentration

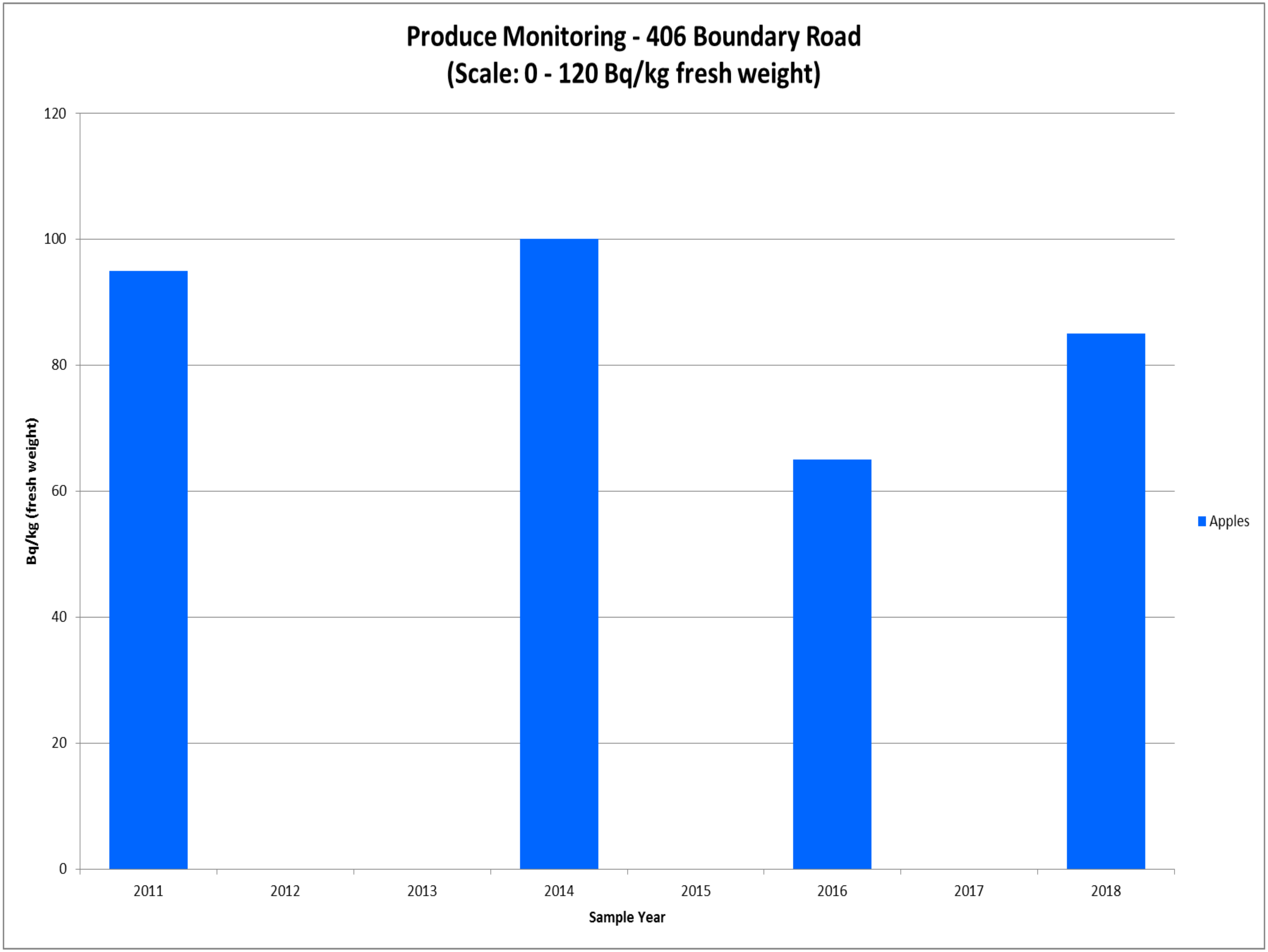
Sample	Units	Result
Tomatoes 408 Boundary Road	Bq/kg Fresh weight	4

2018 Commercial Produce Sampling – Free-water Tritium Concentration

Sample	Units	Result
Onion – Biedermann	Bq/kg Fresh weight	4
Cucumber - Biedermann	Bq/kg Fresh weight	4
Pumpkin - Biedermann	Bq/kg Fresh weight	4

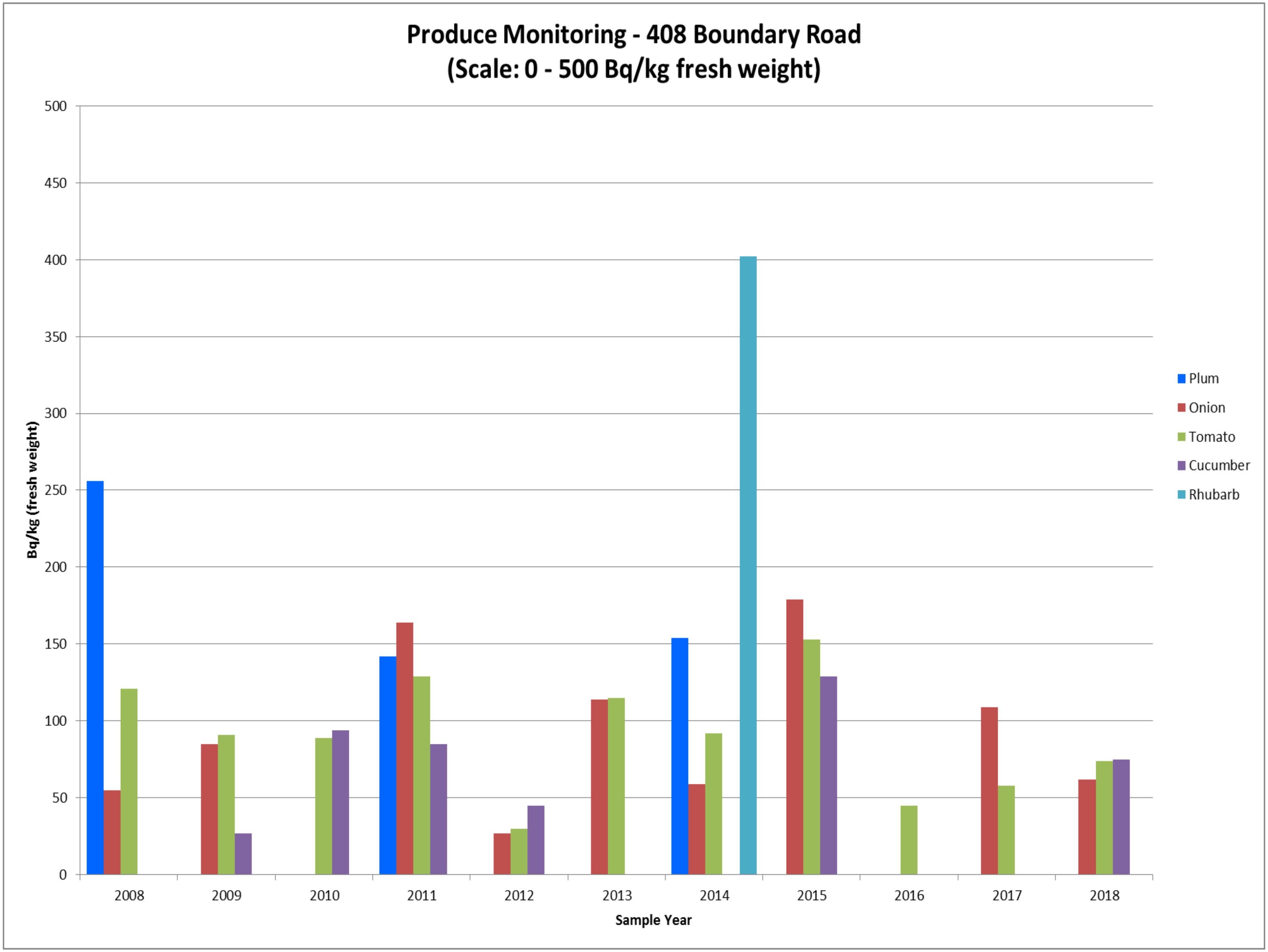
2018 Commercial Produce Sampling – Organically-bound Tritium (OBT) Concentration

Sample	Units	Result
Pumpkin - Biedermann	Bq/kg Fresh weight	3

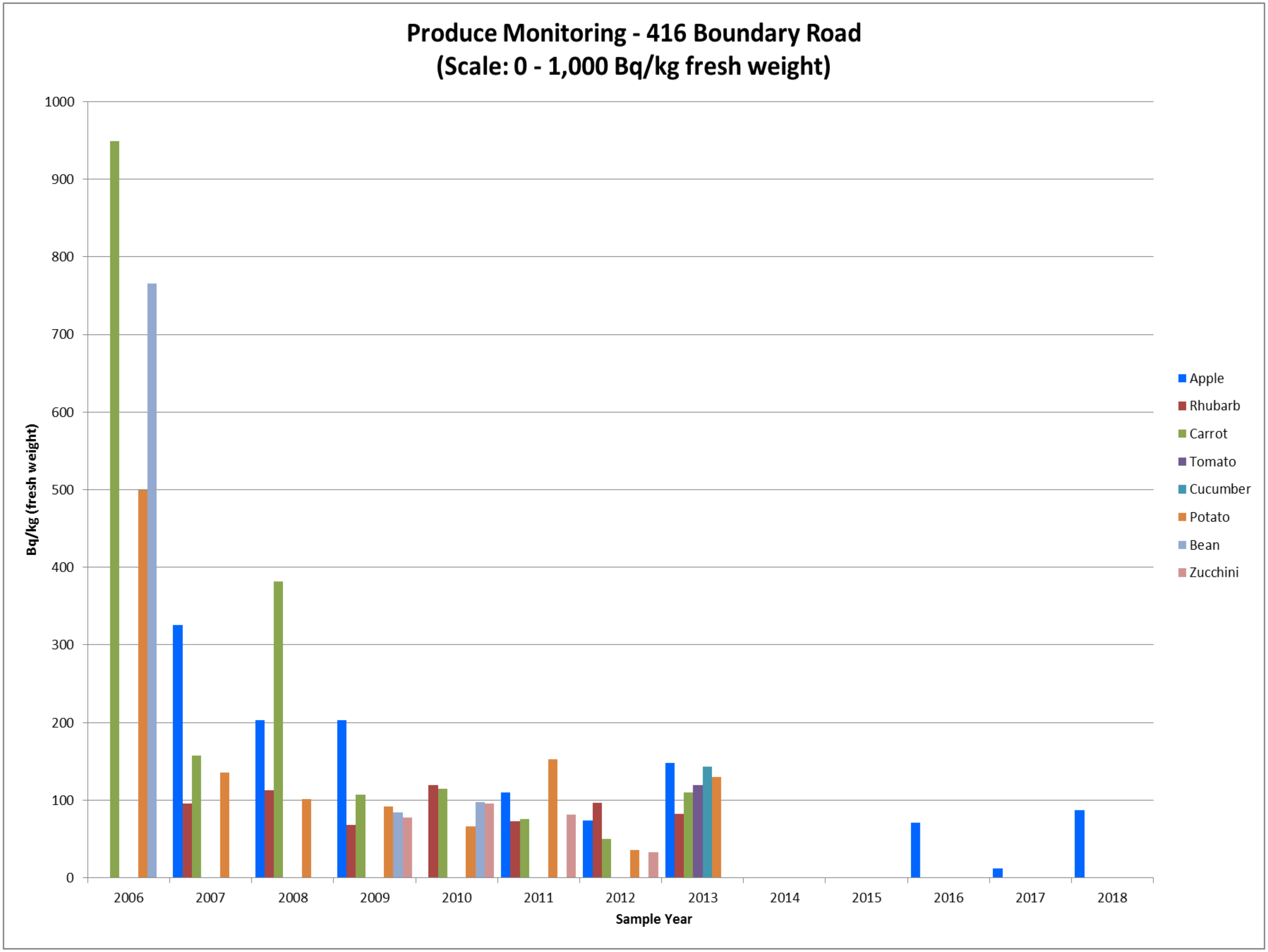


Produce Monitoring - 406 Boundary Road
(Scale: 0 - 120 Bq/kg fresh weight)
120
100
80
60
40
20
0
Bq/kg (fresh weight)
2011
2012
2013
2014
2015
2016
2017
2018
Sample Year
Apples

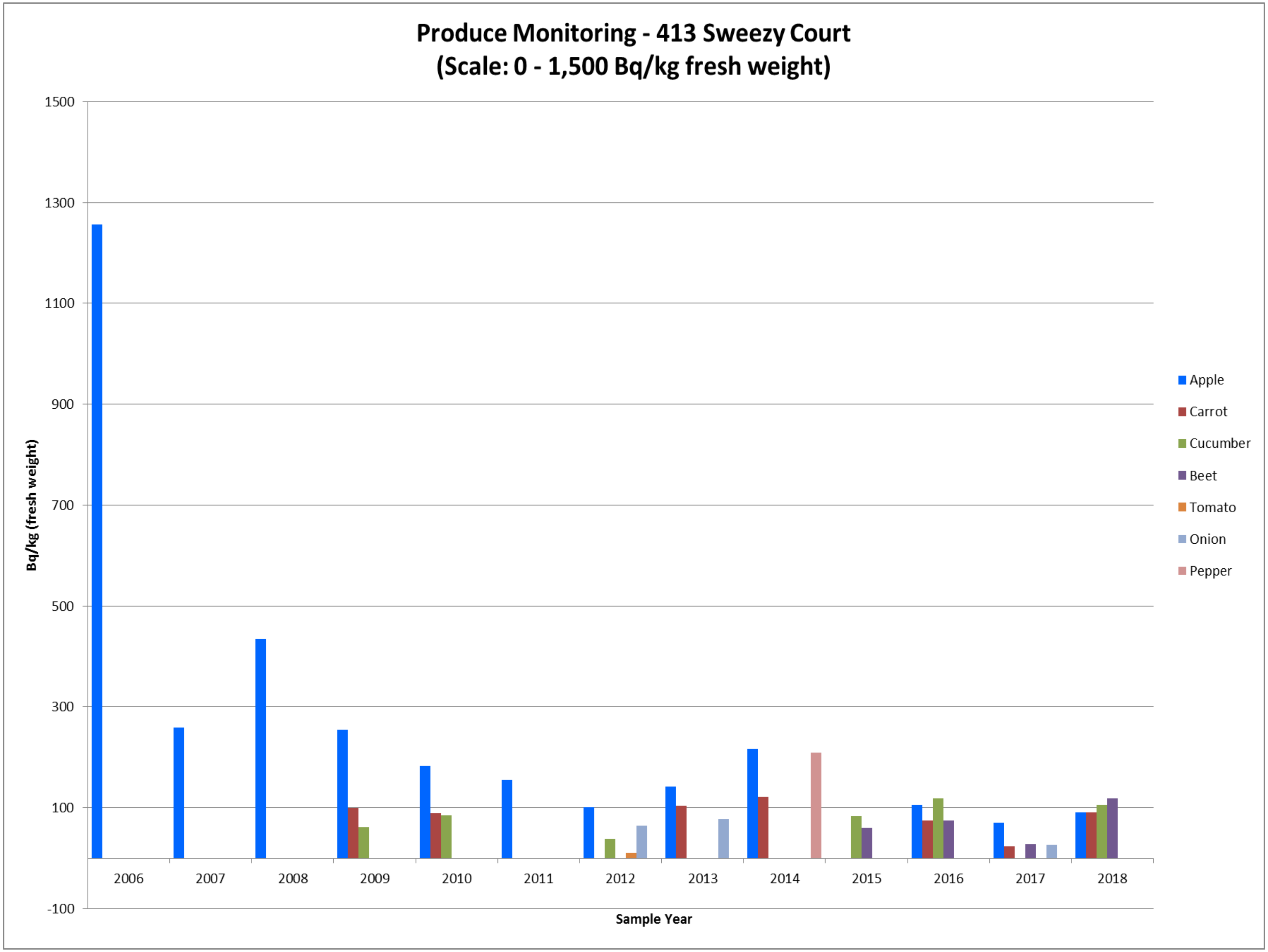
APPENDIX K


Produce Monitoring - 408 Boundary Road
(Scale: 0 - 500 Bq/kg fresh weight)
Bq/kg (fresh weight)
500
450
400
350
300
250
200
150
100
50
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Sample Year
Plum
Onion
Tomato
Cucumber
Rhubarb

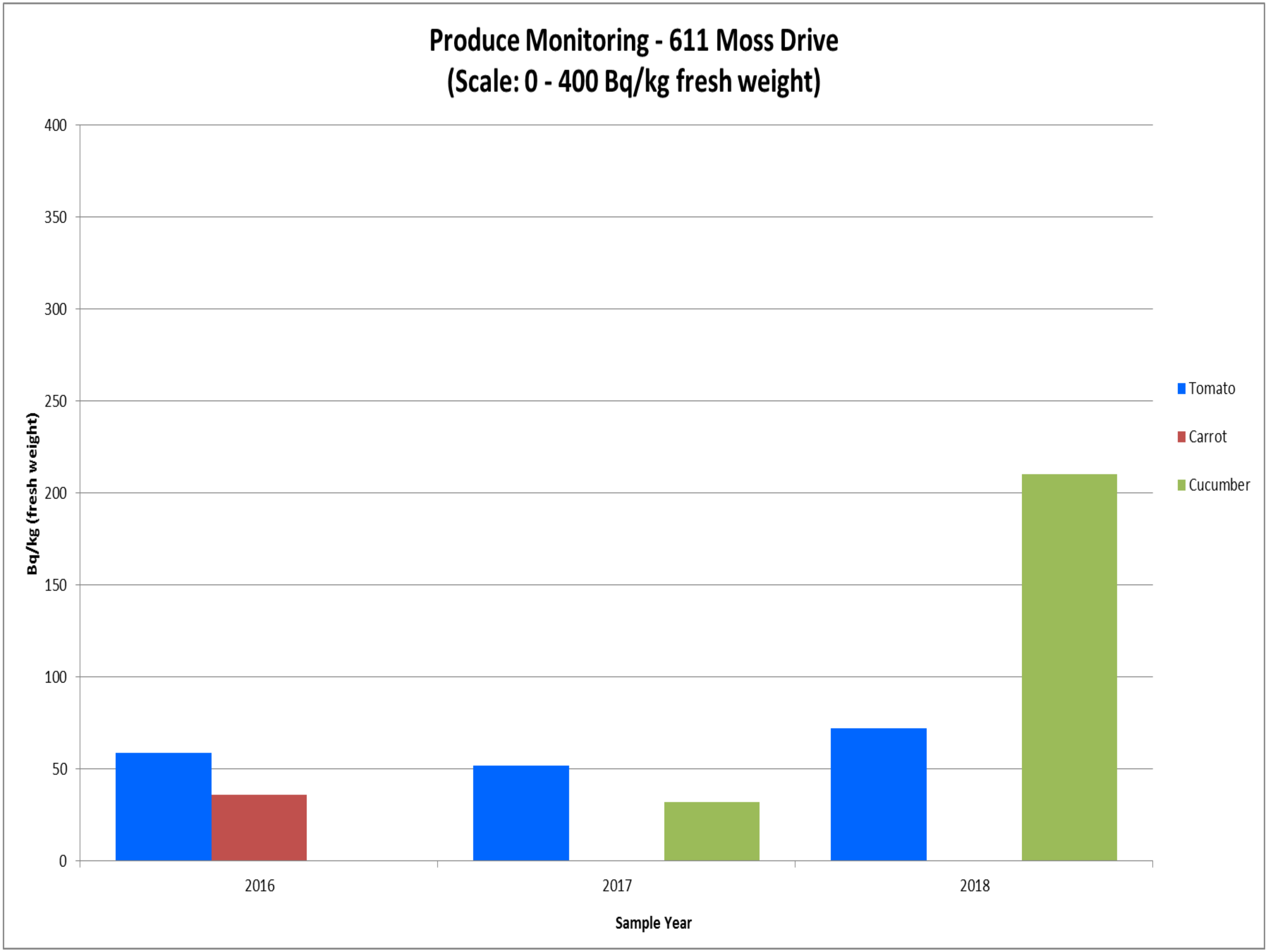
APPENDIX K


Produce Monitoring - 416 Boundary Road
(Scale: 0 - 1,000 Bq/kg fresh weight)
Bq/kg (fresh weight)
1000
900
800
700
600
500
400
300
200
100
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Sample Year
Apple
Rhubarb
Carrot
Tomato
Cucumber
Potato
Bean
Zucchini

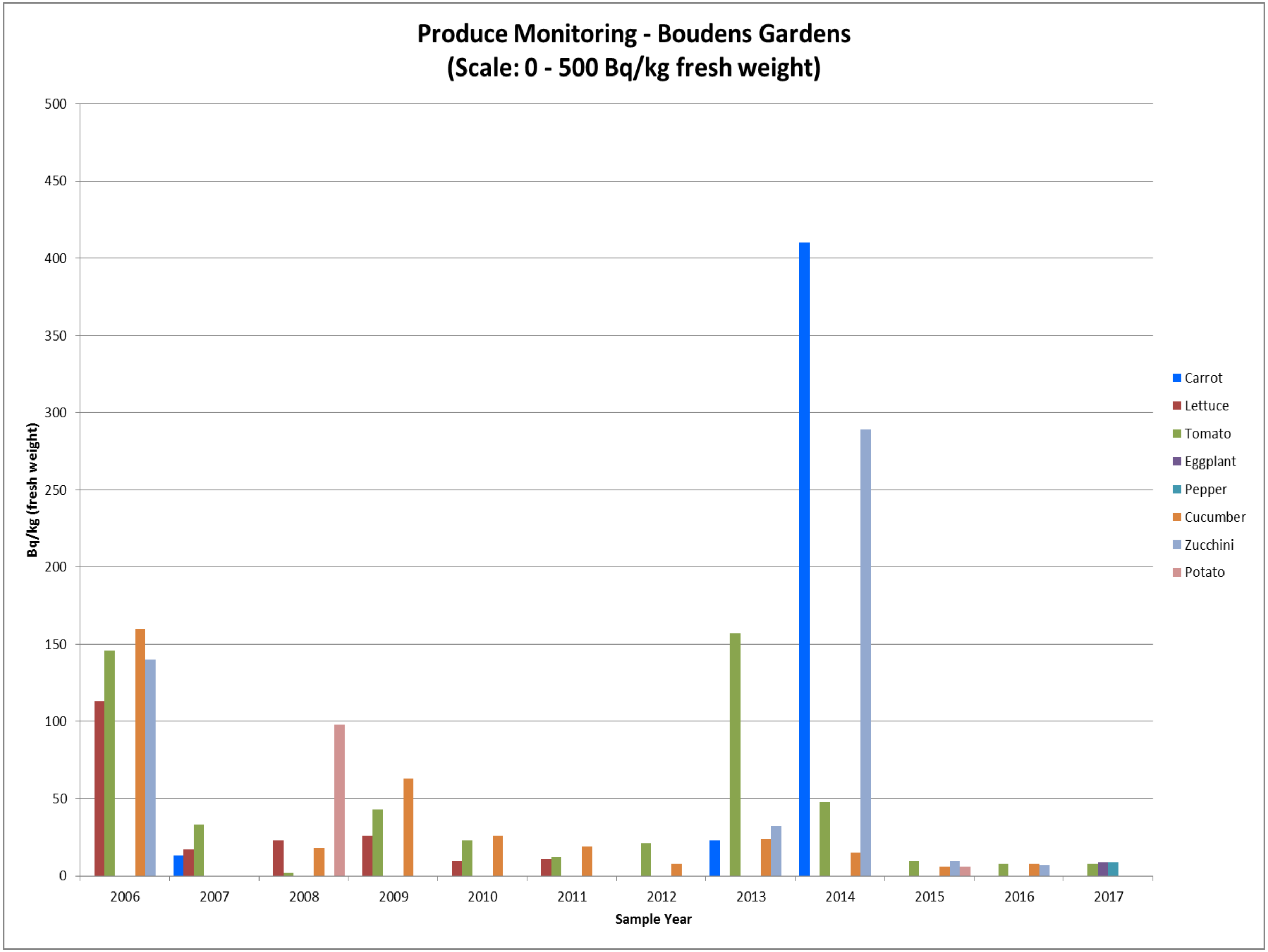
APPENDIX K


Produce Monitoring - 413 Sweezy Court
(Scale: 0 - 1,500 Bq/kg fresh weight)
1500
1300
1100
900
700
500
300
100
-100
Bq/kg (fresh weight)
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Sample Year
Apple
Carrot
Cucumber
Beet
Tomato
Onion
Pepper

APPENDIX K

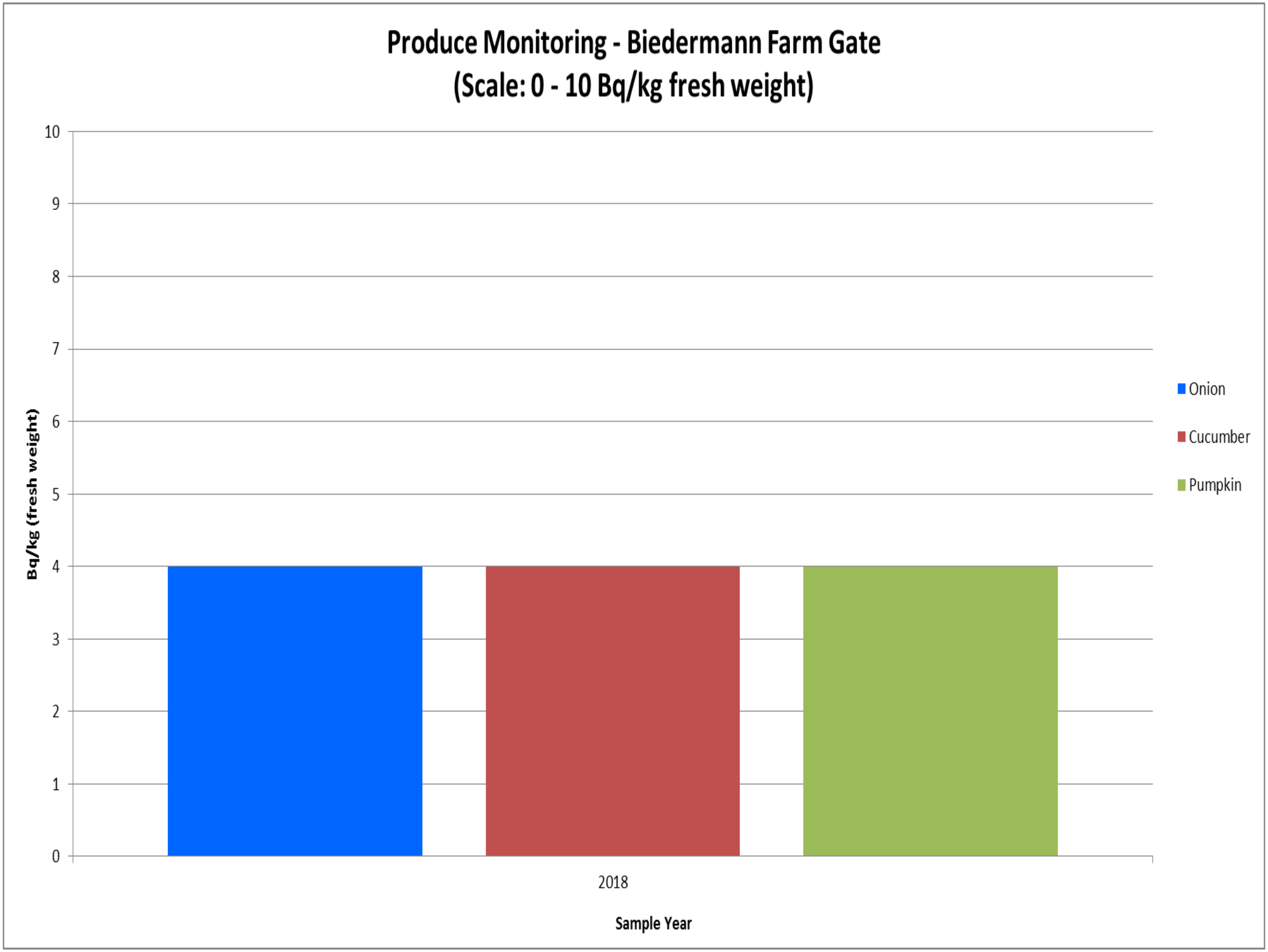

Produce Monitoring - 611 Moss Drive
(Scale: 0 - 400 Bq/kg fresh weight)
Bq/kg (fresh weight)
400
350
300
250
200
150
100
50
0
2016
2017
2018
Sample Year
Tomato
Carrot
Cucumber

APPENDIX K



Produce Monitoring - Boudens Gardens
(Scale: 0 - 500 Bq/kg fresh weight)
Bq/kg (fresh weight)
500
450
400
350
300
250
200
150
100
50
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Sample Year
Carrot
Lettuce
Tomato
Eggplant
Pepper
Cucumber
Zucchini
Potato

APPENDIX K


Produce Monitoring - Biedermann Farm Gate
(Scale: 0 - 10 Bq/kg fresh weight)
10
9
8
7
6
5
4
3
2
1
0
Bq/kg (fresh weight)
2018
Sample Year
Onion
Cucumber
Pumpkin

APPENDIX K

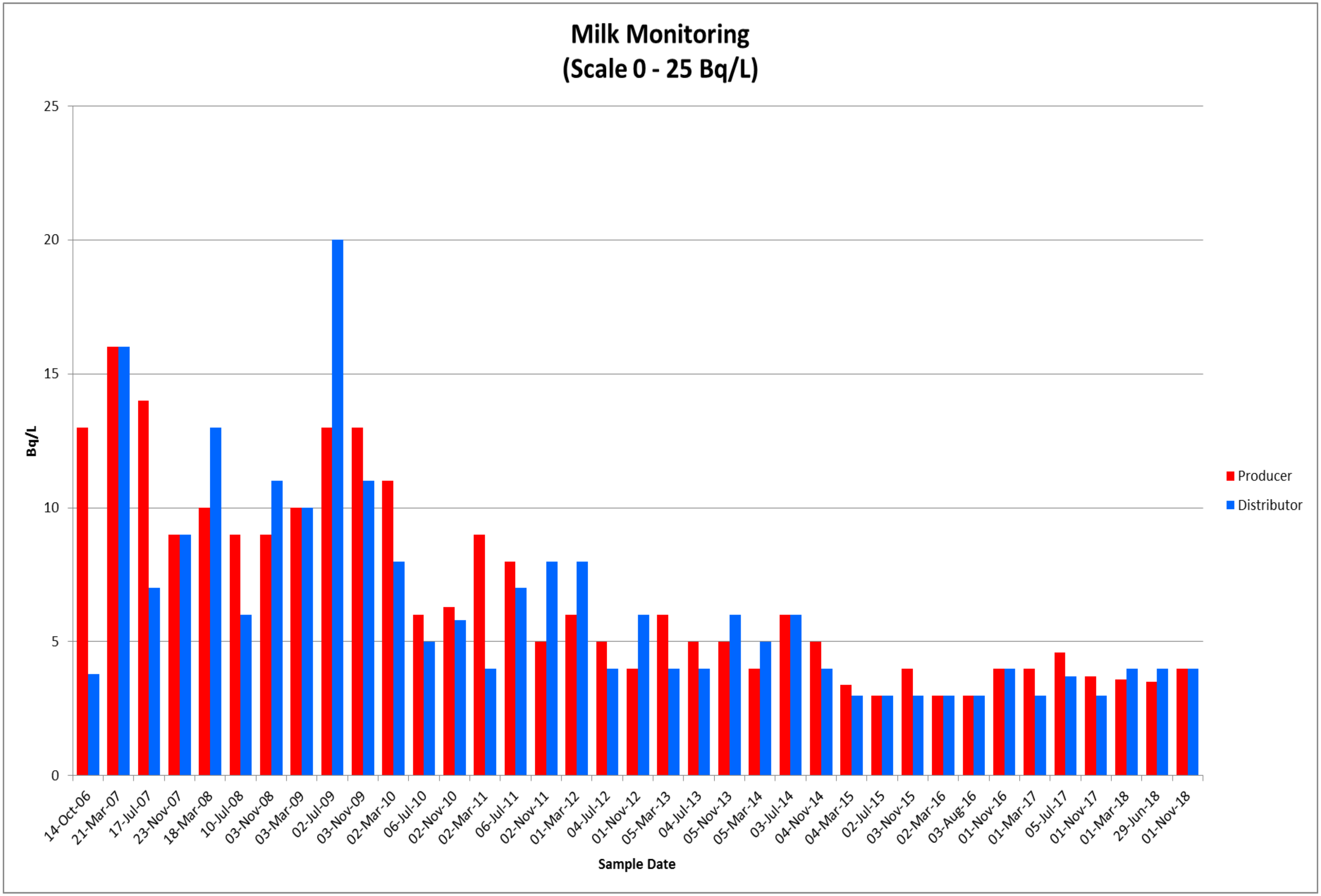
APPENDIX L

Milk Monitoring Results for 2018

MILK MONITORING

Results shaded in blue are <MDA (minimum detectable activity)

	LOCAL MILK PRODUCER	LOCAL MILK DISTRIBUTOR
	Bq/L	Bq/L
14-Oct-06	13	3.8
21-Mar-07	16	16
17-Jul-07	14	7
23-Nov-07	9	9
18-Mar-08	10	13
10-Jul-08	9	6
03-Nov-08	9	11
03-Mar-09	10	10
02-Jul-09	13	20
03-Nov-09	13	11
02-Mar-10	11	8
06-Jul-10	6	5
02-Nov-10	6.3	5.8
02-Mar-11	9	4
06-Jul-11	8	7
02-Nov-11	5	8
01-Mar-12	6	8
04-Jul-12	5	4
01-Nov-12	4	6
05-Mar-13	6	4
04-Jul-13	5	4
05-Nov-13	5	6
05-Mar-14	4	5
03-Jul-14	6	6
04-Nov-14	5	4
04-Mar-15	3.4	3
02-Jul-15	3	3
03-Nov-15	4	3
02-Mar-16	3	3
03-Aug-16	3	3
01-Nov-16	4	4
01-Mar-17	4	3
05-Jul-17	4.6	3.7
01-Nov-17	3.7	3
01-Mar-18	3.6	4
29-Jun-18	3.5	4
01-Nov-18	4	4



Milk Monitoring
(Scale 0 - 25 Bq/L)
25
20
15
10
5
0
Bq/L
Producer
Distributor
14-Oct-06
21-Mar-07
17-Jul-07
23-Nov-07
18-Mar-08
10-Jul-08
03-Nov-08
03-Mar-09
02-Jul-09
03-Nov-09
02-Mar-10
06-Jul-10
02-Nov-10
02-Mar-11
06-Jul-11
02-Nov-11
01-Mar-12
04-Jul-12
01-Nov-12
05-Mar-13
04-Jul-13
05-Nov-13
05-Mar-14
03-Jul-14
04-Nov-14
04-Mar-15
02-Jul-15
03-Nov-15
02-Mar-16
03-Aug-16
01-Nov-16
01-Mar-17
05-Jul-17
01-Nov-17
01-Mar-18
29-Jun-18
01-Nov-18
Sample Date

APPENDIX L

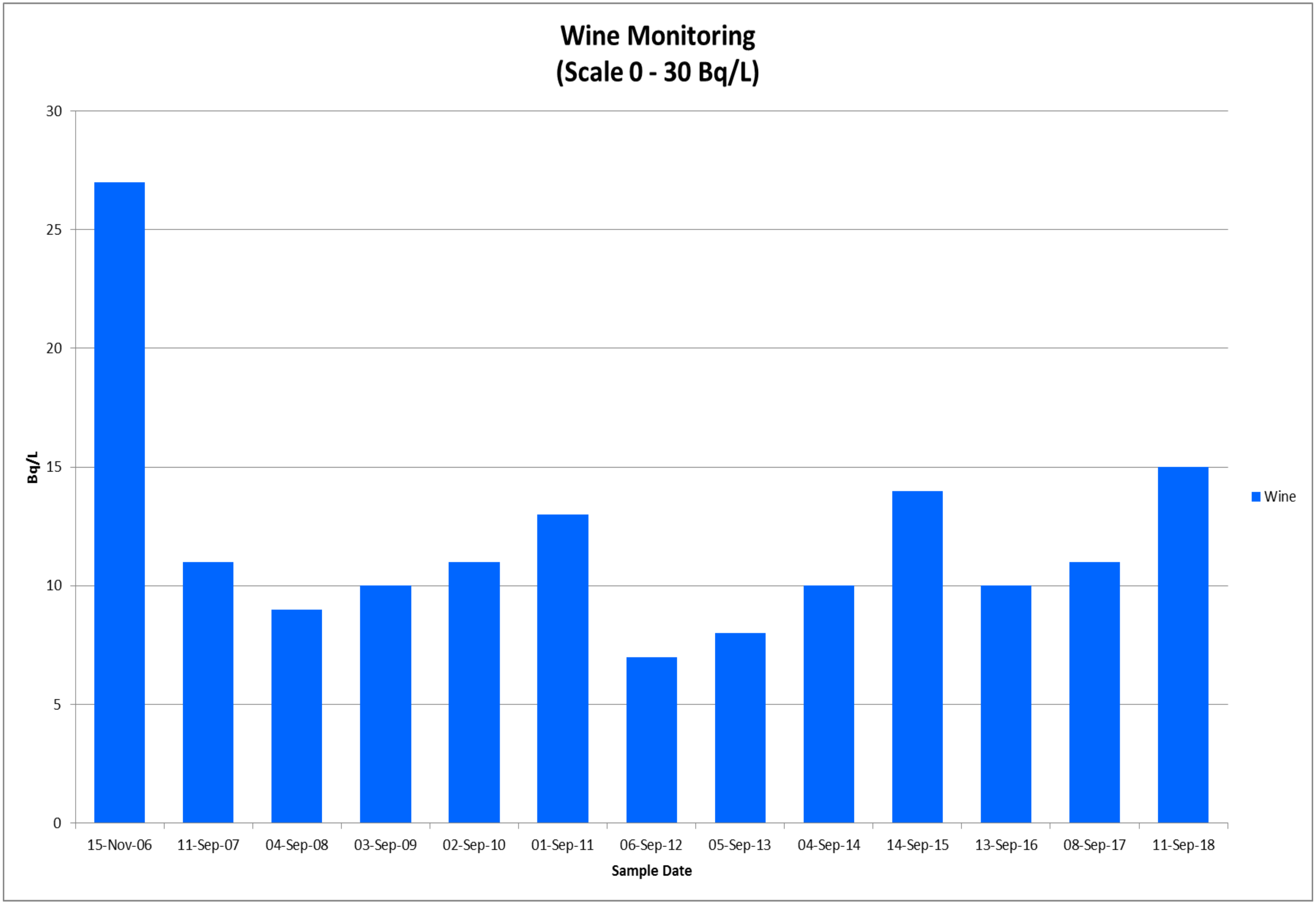
APPENDIX M

Wine Monitoring Results for 2018

WINE MONITORING

Results shaded in blue are <MDA (minimum detectable activity)

	Bq/L
15-Nov-06	27
11-Sep-07	11
04-Sep-08	9
03-Sep-09	10
02-Sep-10	11
01-Sep-11	13
06-Sep-12	7
05-Sep-13	8
04-Sep-14	10
14-Sep-15	14
13-Sep-16	10
08-Sep-17	11
11-Sep-18	15


Wine Monitoring
(Scale 0 - 30 Bq/L)
30
25
20
15
10
5
0
Bq/L
Wine
15-Nov-06
11-Sep-07
04-Sep-08
03-Sep-09
02-Sep-10
01-Sep-11
06-Sep-12
05-Sep-13
04-Sep-14
14-Sep-15
13-Sep-16
08-Sep-17
11-Sep-18
Sample Date

APPENDIX N

Weather Data for 2018

WEATHER DATA SUMMARY (2014-2018)									
Month	Precip Counts, # (TOTAL)	Wind Speed, m/s (AVG)	Gust Speed, m/s (AVG)	Wind Direction, ø (AVG)	Temp, °C (AVG)	RH, % (AVG)	DewPt, °C (AVG)	Wind sector (nesw)	Total rain (mm)
January-2014	126	3.1	4.4	179.9	-10.2	77.5	-13.5	SSE	25.2
February-2014	36	3.0	4.4	163.4	-10.6	70.1	-15.2	SSE	7.2
March-2014	63	3.3	4.8	146.1	-5.4	66.6	-10.9	SE	12.6
April-2014	469	3.3	4.9	145.9	4.9	68.9	-1.1	SE	93.8
May-2014	327	2.6	4.0	193.1	14.3	67.1	7.5	SSW	65.4
June-2014	675	2.3	3.6	209.9	19.1	71.3	13.1	SSW	135
July-2014	609	2.1	3.3	251.3	18.8	75.4	14.0	WSW	121.8
August-2014	417	2.3	3.4	232.0	18.3	81.2	14.6	SW	83.4
September-2014	371	2.2	3.4	185.8	13.8	82.6	10.6	SSW	74.2
October-2014	477	2.8	4.3	164.5	8.4	82.8	5.5	SSE	95.4
November-2014	123	3.0	4.7	212.7	-1.2	79.6	-4.3	SW	24.6
December-2014	178	2.7	4.2	209.5	-7.4	82.0	-10.0	SSW	35.6
January-2015	19	2.6	3.8	228.1	-14.2	75.4	-17.7	SW	3.8
February-2015	20	2.8	4.1	220.5	-15.2	70.9	-19.6	SW	4.0
March-2015	88	2.7	4.2	204.2	-3.7	64.7	-9.9	SSW	17.6
April-2015	179	3.2	5.0	227.1	7.3	61.4	-0.7	SW	35.8
May-2015	453	2.8	4.4	199.4	15.1	66.4	7.9	SSW	90.6
June-2015	549	2.4	3.7	212.6	17.4	73.7	12.1	SW	109.8
July-2015	313	2.1	3.3	163.9	20.6	74.6	15.4	SSE	62.6
August-2015	357	1.9	3.0	146.0	19.3	80.6	15.6	SE	71.4
September-2015	163	2.1	3.3	203.5	16.8	77.5	12.5	SSW	32.6
October-2015	372	2.8	4.3	188.5	7.0	78.2	3.2	SSW	74.4
November-2015	197	2.6	3.9	160.6	3.0	82.7	0.2	SSE	39.4
December-2015	240	2.8	4.2	177.4	-0.8	84.3	-3.2	SSE	48
January-2016	151	3.1	4.4	166.1	-7.5	83.6	-9.9	SSE	30.2
February-2016	122	2.7	4.1	171.8	-9.7	77.7	-13.0	SSE	24.4
July-2016	401	1.9	3.2	254.8	21.3	72.5	15.7	WSW	80.2
August-2016	576	2.1	3.4	268.3	21.2	74.9	16.1	WSW	115.2
September-2016	331	1.8	2.9	230.0	15.8	79.7	12.0	SW	66.2
October-2016	140	2.9	4.4	214.9	7.9	80.1	4.4	SW	28
November-2016	330	2.7	4.1	192.2	3.0	84.5	0.4	SSW	66
December-2016	165	2.9	4.2	184.2	-5.8	83.1	-8.2	SSW	33
January-2017	113	3.0	4.4	187.5	-5.8	82.0	-8.4	SSW	22.6
February-2017	246	2.8	4.1	160.3	-5.2	79.4	-8.4	SSE	49.2
March-2017	209	2.9	4.4	227.5	-4.7	67.0	-10.3	SW	41.8
April-2017	857	2.6	4.1	179.4	6.8	75.1	2.1	SSE	171.4
May-2017	552	2.6	4.2	202.9	11.9	74.4	6.9	SSW	110.4
June-2017	1041	2.2	3.5	249.5	18.2	75.0	13.1	WSW	208.2
July-2017	712	1.7	2.8	221.6	20.0	76.0	15.2	SW	142.4
August-2017	433	2.0	3.3	241.1	17.5	79.3	13.6	WSW	86.6
September-2017	284	1.4	2.3	227.9	16.2	81.5	12.7	SW	56.8
October-2017	534	2.5	4.0	210.1	11.0	79.4	7.3	SSW	106.8
November-2017	286	3.2	4.6	162.8	-0.4	79.4	-3.7	SSE	57.2
December-2017	79	2.8	4.1	135.1	-10.9	79.2	-13.8	SE	15.8
January-2018	167	3.3	4.9	146.0	-9.7	80.2	-12.6	SE	33.4
February-2018	169	3.3	3.7	154.8	-5.6	77.9	-9.1	SSE	33.8
March-2018	158	3.9	5.1	94.1	-2.3	68.6	-7.7	ESE	31.6
April-2018	348	2.8	4.2	146.6	3.5	66.5	-3.1	SE	69.6
May-2018	276	2.4	3.9	202.6	15.1	60.7	6.4	SSW	55.2
June-2018	273	2.1	3.4	221.4	17.2	70.1	11.0	SW	54.6
July-2018	340	2.1	3.3	250.8	22.4	69.7	15.9	WSW	68
August-2018	336	1.8	2.9	213.2	21.0	78.7	16.8	SW	67.2
September-2018	352	2.1	3.3	205.2	14.5	81.1	11.1	SSW	70.4
October-2018	234	2.8	4.3	213.7	6.0	79.0	2.4	SW	46.8
November-2018	352	2.9	4.3	204.3	-2.3	85.6	-4.4	SSW	70.4
December-2018	170	2.3	3.4	195.0	-8.0	85.6	-10.0	SSW	34

APPENDIX O

Well Monitoring Results for 2018

Groundwater Tritium Concentration Summary 2018

WELL I.D.	DESCRIPTION		DISTANCE FROM STACKS (m)	Jan. 4, 2018	Feb. 1, 2018	Mar. 1, 2018	Apr. 4, 2018	May 3, 2018	Jun. 1, 2018	Jun. 29, 2018	Aug. 1, 2018	Sep. 5, 2018	Oct. 2, 2018	Nov. 2, 2018	Dec. 4, 2018	WELL I.D.
MW06-1	SRB SITE	IN SOIL	50	1,568	1,570	1,439	1,426	1,515	1,278	1,258	1,160	1,253	1,232	1,237	1,073	MW06-1
MW06-2	SRB SITE	IN SOIL	75	1,140	1,169	1,162	1,175	1,224	1,061	1,132	1,156	1,199	1,193	1,181	1,122	MW06-2
MW06-3	SRB SITE	IN SOIL	50	519	568	494	429	487	368	422	DRY	DRY	DRY	DRY	461	MW06-3
MW06-8	SRB SITE	IN SOIL	55	743	742	763	747	806	693	686	718	730	703	675	676	MW06-8
MW06-9	SRB SITE	IN SOIL	25	2,035	2,073	2,035	2,008	2,049	1,919	1,929	1,915	1,933	1,906	1,814	1,807	MW06-9
MW06-10	SRB SITE	SURFACE OF BEDROCK	0	51,809	44,910	42,668	26,617	28,501	21,859	36,608	46,701	48,162	47,800	44,642	42,219	MW06-10
MW07-11	SRB SITE	SURFACE OF BEDROCK	75	1,197	1,242	1,273	1,109	1,033	895	1,031	1,171	1,181	1,145	1,137	1,051	MW07-11
MW07-12	SRB SITE	SURFACE OF BEDROCK	55	472	488	506	545	513	428	426	469	472	429	404	458	MW07-12
MW07-13	SRB SITE	SURFACE OF BEDROCK	50	7,785	7,753	7,527	7,388	6,223	6,542	6,694	6,826	6,929	6,787	6,518	6,268	MW07-13
MW07-15	SRB SITE	SURFACE OF BEDROCK	25	1,557	1,369	1,602	1,543	1,628	1,438	1,472	1,504	1,531	1,494	1,461	1,458	MW07-15
MW07-16	SRB SITE	SURFACE OF BEDROCK	15	1,549	1,479	1,489	1,445	1,610	1,384	1,361	1,449	1,467	1,364	1,308	1,286	MW07-16
MW07-17	SRB SITE	DEEPER BEDROCK	15	252	298	374	399	390	222	265	364	421	426	421	473	MW07-17
MW07-18	SRB SITE	SURFACE OF BEDROCK	10	2,381	2,479	2,679	2,213	1,885	1,832	1,983	2,237	2,426	2,183	2,101	1,910	MW07-18
MW07-19	SRB SITE	SURFACE OF BEDROCK	20	2,210	1,887	1,632	1,972	1,953	1,356	1,648	2,125	2,230	2,029	1,963	1,666	MW07-19
MW07-20	SUPERIOR PROPANE PROPERTY	SURFACE OF BEDROCK	90	517	529	510	500	550	460	490	494	518	471	462	472	MW07-20
MW07-21	SUPERIOR PROPANE PROPERTY	SURFACE OF BEDROCK	110	773	907	629	808	836	731	756	782	817	772	772	748	MW07-21
MW07-22	SRB SITE	SURFACE OF BEDROCK	70	1,016	1,079	1,063	915	935	885	856	1,001	994	1,009	974	955	MW07-22
MW07-23	SRB SITE	SURFACE OF BEDROCK	90	1,603	1,608	1,588	1,651	1,622	1,521	1,540	1,578	1,622	1,507	1,513	1,509	MW07-23
MW07-24	HARRINGTON PROPERTY	SURFACE OF BEDROCK	115	1,957	1,990	1,970	2,067	1,985	1,829	1,860	1,877	1,961	1,889	1,873	1,880	MW07-24
MW07-26	SRB SITE	SURFACE OF BEDROCK	50	1,130	1,201	1,018	1,004	715	939	934	957	825	733	651	738	MW07-26
MW07-27	CITY PROPERTY	SURFACE OF BEDROCK	55	3,510	3,613	3,528	3,335	1,270	2,244	2,626	3,432	3,526	3,576	3,510	3,460	MW07-27
MW07-28	CITY PROPERTY	DEEPER BEDROCK	55	1,096	1,030	889	1,068	1,190	1,081	996	940	1,068	953	921	970	MW07-28
MW07-29	SRB SITE	DEEPER BEDROCK	10	2,197	2,586	2,454	1,966	1,613	1,524	2,121	2,754	2,987	3,302	3,058	2,416	MW07-29
MW07-31	SRB SITE	DEEPER BEDROCK	70	186	359	502	176	149	231	431	547	617	623	584	483	MW07-31
MW07-32	HARRINGTON PROPERTY	DEEPER BEDROCK	115	45	101	71	109	48	62	<MDA (46)	51	<MDA (41)	<MDA (42)	<MDA (39)	<MDA (36)	MW07-32
MW07-34	SRB SITE	SHALLOW BEDROCK	10	1,949	1,881	1,835	1,828	2,058	1,938	1,889	1,887	1,817	2,006	1,847	1,737	MW07-34
MW07-35	CITY PROPERTY	SHALLOW BEDROCK	55	2,700	2,745	2,684	2,569	2,441	2,375	2,407	2,532	2,577	2,807	3,084	2,722	MW07-35
MW07-36	CITY PROPERTY	SHALLOW BEDROCK	80	2,258	2,306	2,032	2,053	1,605	1,614	1,883	2,071	2,084	2,133	2,084	1,969	MW07-36
MW07-37	SRB SITE	SHALLOW BEDROCK	60	868	835	827	785	750	707	741	816	875	895	942	918	MW07-37
CN-1S	CN PROPERTY		125			216				Dry				Dry		CN-1S
CN-1D	CN PROPERTY		130			469				473				Dry		CN-1D
CN-2	CN PROPERTY		150			130				332				380		CN-2
CN-3S	CN PROPERTY		165			142				96				Dry		CN-3S
CN-3D	CN PROPERTY		160			252				329				Dry		CN-3D
RW-2	185 MUD LAKE ROAD		1,100			47				48				39		RW-2
RW-3	183 MUD LAKE ROAD		1,100			53				55				57		RW-3
RW-5	171 SAWMILL ROAD		2,300			6				7				5		RW-5
RW-6	40987 HWY 41		1,400			6				6				7		RW-6
RW-7	40925 HWY 41		1,600			<4				<3				<3		RW-7
RW-8	204 BOUNDARY ROAD		700			120										RW-8
RW-9	206 BOUNDARY ROAD		650													RW-9
RW-10	208 BOUNDARY ROAD		625													RW-10
RW-12	202 MUD LAKE ROAD		753													RW-12
B-1	VALLEY POOL SERVICE OFFICE		160			967				1,130				1,043		B-1
B-2	SUPERIOR PROPANE TRUCK WASH		250			746				591				742		B-2
B-3	HEIDEMAN & SONS LUMBER		385			<4				<3				<3		B-3

NOTE 1 *(March) RW-9, -10 and -12 have all notified SRBT that they have transitioned to the municipal water supply, and that their well has been disconnected.*

NOTE 2 *(July) RW-8 notified SRBT that they have transitioned to the municipal water supply, and that their well has been disconnected.*

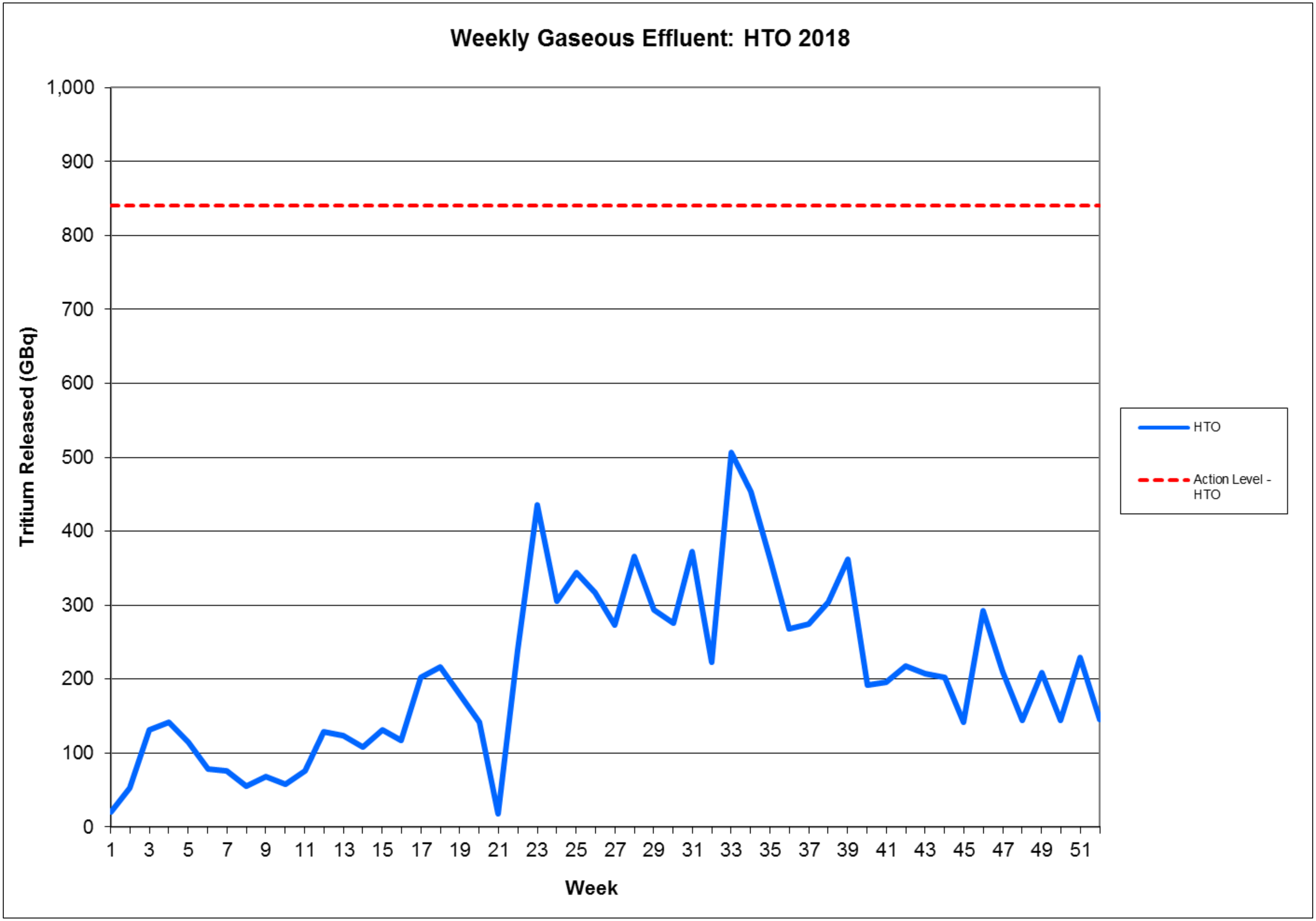
APPENDIX P

Gaseous Effluent Data for 2018

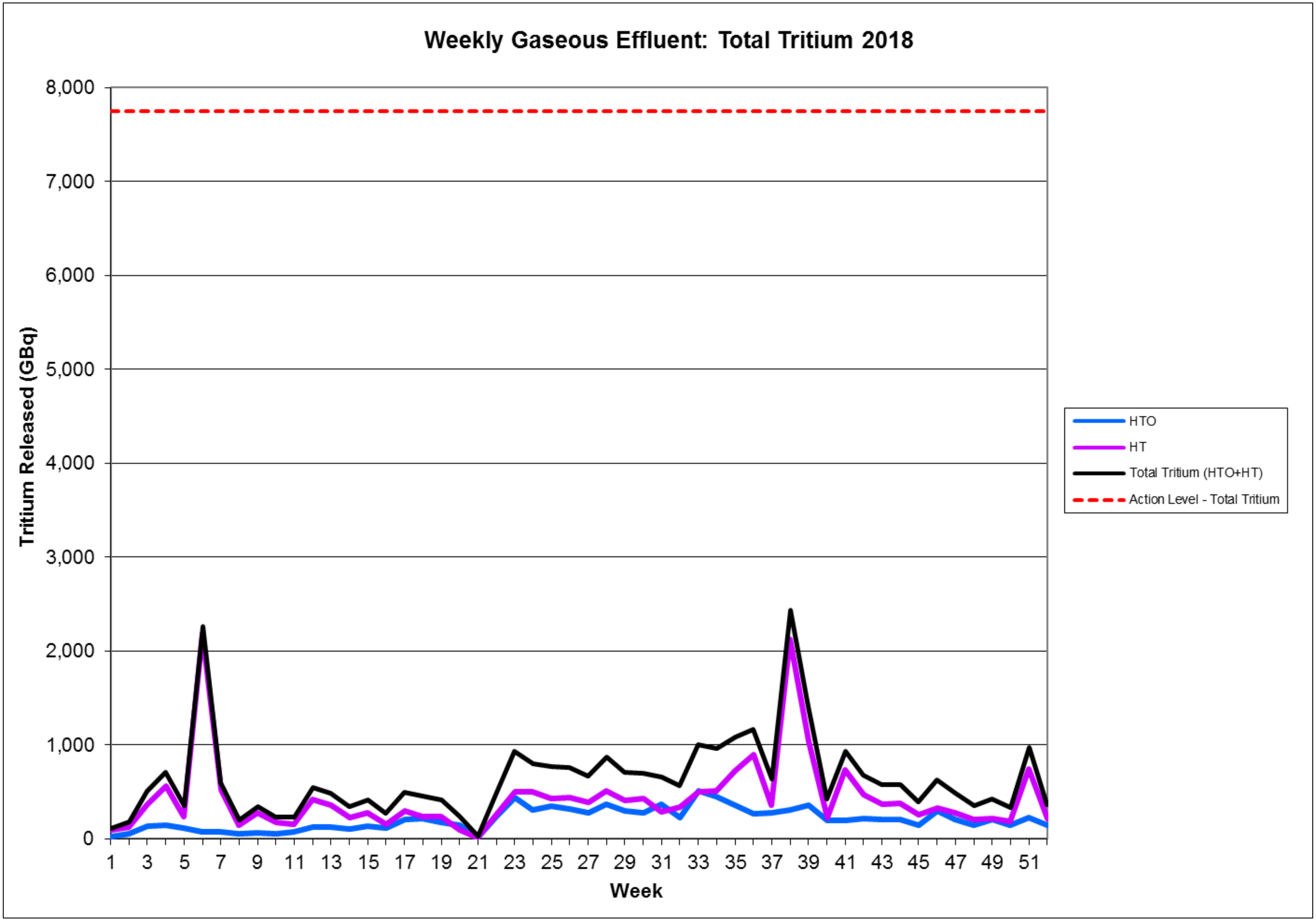
2018 Gaseous Effluent Data

Week	Date		H-3 in Air (GBq)			(GBq)		% 2016 SRBT DRL (12 hr. TJF Data)				Weekly Action Levels	
	Initial	Final	HTO	HT	Total	∑(HTO)	∑(HTO + HT)	1 year old	10 year old	Adult Resident	Adult Worker	HTO (840 GBq)	HTO+HT (7,753 GBq)
1	26/12/2017	02/01/2018	20.59	91.65	112.24	20.59	112.24	0.01	0.01	0.01	0.01	2%	1%
2	02/01/2018	09/01/2018	52.68	127.47	180.15	73.27	292.39	0.03	0.03	0.03	0.03	6%	2%
3	09/01/2018	16/01/2018	131.65	372.36	504.01	204.92	796.40	0.06	0.08	0.07	0.09	16%	7%
4	16/01/2018	23/01/2018	141.82	562.30	704.12	346.74	1500.52	0.07	0.09	0.08	0.10	17%	9%
5	23/01/2018	30/01/2018	114.69	241.31	356.00	461.43	1856.52	0.06	0.07	0.06	0.07	14%	5%
6	30/01/2018	06/02/2018	77.98	2183.43	2261.41	539.41	4117.93	0.07	0.08	0.08	0.09	9%	29%
7	06/02/2018	13/02/2018	75.83	519.49	595.32	615.24	4713.25	0.04	0.05	0.05	0.06	9%	8%
8	13/02/2018	20/02/2018	55.82	147.02	202.84	671.06	4916.09	0.03	0.03	0.03	0.04	7%	3%
9	20/02/2018	27/02/2018	67.77	274.24	342.01	738.83	5258.10	0.03	0.04	0.04	0.05	8%	4%
10	27/02/2018	06/03/2018	57.99	171.96	229.95	796.82	5488.05	0.03	0.03	0.03	0.04	7%	3%
11	06/03/2018	13/03/2018	75.37	151.89	227.26	872.19	5715.31	0.04	0.04	0.04	0.05	9%	3%
12	13/03/2018	20/03/2018	128.83	420.51	549.34	1001.02	6264.65	0.06	0.08	0.07	0.09	15%	7%
13	20/03/2018	27/03/2018	123.36	357.89	481.25	1124.38	6745.90	0.06	0.07	0.07	0.08	15%	6%
14	27/03/2018	03/04/2018	107.97	231.66	339.63	1232.35	7085.53	0.05	0.06	0.06	0.07	13%	4%
15	03/04/2018	10/04/2018	130.65	278.85	409.50	1363.00	7495.03	0.06	0.07	0.07	0.09	16%	5%
16	10/04/2018	17/04/2018	116.54	152.63	269.17	1479.54	7764.20	0.05	0.06	0.06	0.07	14%	3%
17	17/04/2018	24/04/2018	202.84	294.66	497.50	1682.38	8261.70	0.10	0.11	0.10	0.13	24%	6%
18	24/04/2018	01/05/2018	215.78	238.07	453.85	1898.16	8715.55	0.10	0.12	0.11	0.14	26%	6%
19	01/05/2018	08/05/2018	178.64	240.25	418.89	2076.80	9134.44	0.08	0.10	0.09	0.11	21%	5%
20	08/05/2018	15/05/2018	141.05	98.05	239.10	2217.85	9373.54	0.06	0.08	0.07	0.09	17%	3%
21	15/05/2018	22/05/2018	18.07	12.96	31.03	2235.92	9404.57	0.01	0.01	0.01	0.01	2%	0%
22	22/05/2018	29/05/2018	239.75	258.00	497.75	2475.67	9902.32	0.11	0.13	0.12	0.15	29%	6%
23	29/05/2018	05/06/2018	435.71	501.21	936.92	2911.38	10839.24	0.20	0.24	0.22	0.28	52%	12%
24	05/06/2018	12/06/2018	305.48	499.49	804.97	3216.86	11644.21	0.14	0.17	0.16	0.20	36%	10%
25	12/06/2018	19/06/2018	344.59	429.28	773.87	3561.45	12418.08	0.16	0.19	0.17	0.22	41%	10%
26	19/06/2018	26/06/2018	316.34	444.79	761.13	3877.79	13179.21	0.15	0.18	0.16	0.20	38%	10%
27	26/06/2018	03/07/2018	273.36	392.28	665.64	4151.15	13844.85	0.13	0.15	0.14	0.17	33%	9%
28	03/07/2018	10/07/2018	365.70	506.24	871.94	4516.85	14716.79	0.17	0.20	0.18	0.23	44%	11%
29	10/07/2018	17/07/2018	293.16	413.06	706.22	4810.01	15423.01	0.14	0.16	0.15	0.19	35%	9%
30	17/07/2018	24/07/2018	275.23	427.91	703.14	5085.24	16126.15	0.13	0.15	0.14	0.18	33%	9%
31	24/07/2018	31/07/2018	372.30	288.46	660.76	5457.54	16786.91	0.17	0.20	0.18	0.23	44%	9%
32	31/07/2018	07/08/2018	223.20	340.77	563.97	5680.74	17350.88	0.11	0.12	0.11	0.14	27%	7%
33	07/08/2018	14/08/2018	506.50	495.95	1002.45	6187.24	18353.33	0.23	0.28	0.25	0.32	60%	13%
34	14/08/2018	21/08/2018	453.66	507.79	961.45	6640.90	19314.78	0.21	0.25	0.23	0.29	54%	12%
35	21/08/2018	28/08/2018	361.06	719.90	1080.96	7001.96	20395.74	0.17	0.20	0.19	0.23	43%	14%
36	28/08/2018	04/09/2018	267.94	900.89	1168.83	7269.90	21564.57	0.13	0.16	0.15	0.18	32%	15%
37	04/09/2018	11/09/2018	274.45	362.73	637.18	7544.35	22201.75	0.13	0.15	0.14	0.17	33%	8%
38	11/09/2018	18/09/2018	303.67	2127.10	2430.77	7848.02	24632.52	0.17	0.20	0.18	0.22	36%	31%
39	18/09/2018	25/09/2018	362.69	1043.60	1406.29	8210.71	26038.81	0.18	0.21	0.19	0.24	43%	18%
40	25/09/2018	02/10/2018	191.28	228.94	420.22	8401.99	26459.03	0.09	0.11	0.10	0.12	23%	5%
41	02/10/2018	09/10/2018	195.86	734.58	930.44	8597.85	27389.47	0.10	0.12	0.11	0.13	23%	12%
42	09/10/2018	16/10/2018	217.62	465.23	682.85	8815.47	28072.32	0.10	0.12	0.11	0.14	26%	9%
43	16/10/2018	23/10/2018	207.51	372.16	579.67	9022.98	28651.99	0.10	0.12	0.11	0.13	25%	7%
44	23/10/2018	30/10/2018	201.75	380.12	581.87	9224.73	29233.86	0.10	0.11	0.10	0.13	24%	8%
45	30/10/2018	06/11/2018	141.15	254.70	395.85	9365.88	29629.71	0.07	0.08	0.07	0.09	17%	5%
46	06/11/2018	13/11/2018	292.81	330.54	623.35	9658.69	30253.06	0.14	0.16	0.15	0.19	35%	8%
47	13/11/2018	20/11/2018	210.49	277.72	488.21	9869.18	30741.27	0.10	0.12	0.11	0.13	25%	6%
48	20/11/2018	27/11/2018	143.70	211.15	354.85	10012.88	31096.12	0.07	0.08	0.07	0.09	17%	5%
49	27/11/2018	04/12/2018	208.23	218.29	426.52	10221.11	31522.64	0.10	0.11	0.10	0.13	25%	6%
50	04/12/2018	11/12/2018	144.66	185.11	329.77	10365.77	31852.41	0.07	0.08	0.07	0.09	17%	4%
51	11/12/2018	18/12/2018	229.22	739.53	968.75	10594.99	32821.16	0.11	0.14	0.12	0.15	27%	12%
52	18/12/2018	25/12/2018	146.06	213.10	359.16	10741.05	33180.32	0.07	0.08	0.07	0.09	17%	5%
	Annual Total		10741.05	22439.27	33180.32			Average % DRL					
	Weekly Average		206.56	431.52	638.08			0.10	0.12	0.11	0.13		
				(Bq/a)	Release Limit			Projected Dose (uSv/a)					
% Annual Release Limit:			HTO	6.72E+13	15.98			0.99	1.18	1.07	1.34		
			HTO + HT	4.48E+14	7.41			1 year old	10 year old	Adult Resident	Adult Worker		
Derived Weekly HTO Release/Emission Limit (GBq/week)								2.24E+05	1.88E+05	2.08E+05	1.63E+05		
Derived Weekly HT Release/ Emission Limit (GBq/week)								6.32E+06	5.61E+06	5.54E+06	5.69E+06		

APPENDIX P



Weekly Gaseous Effluent: HTO 2018
Tritium Released (GBq)
1,000
900
800
700
600
500
400
300
200
100
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51
Week
HTO
Action Level - HTO

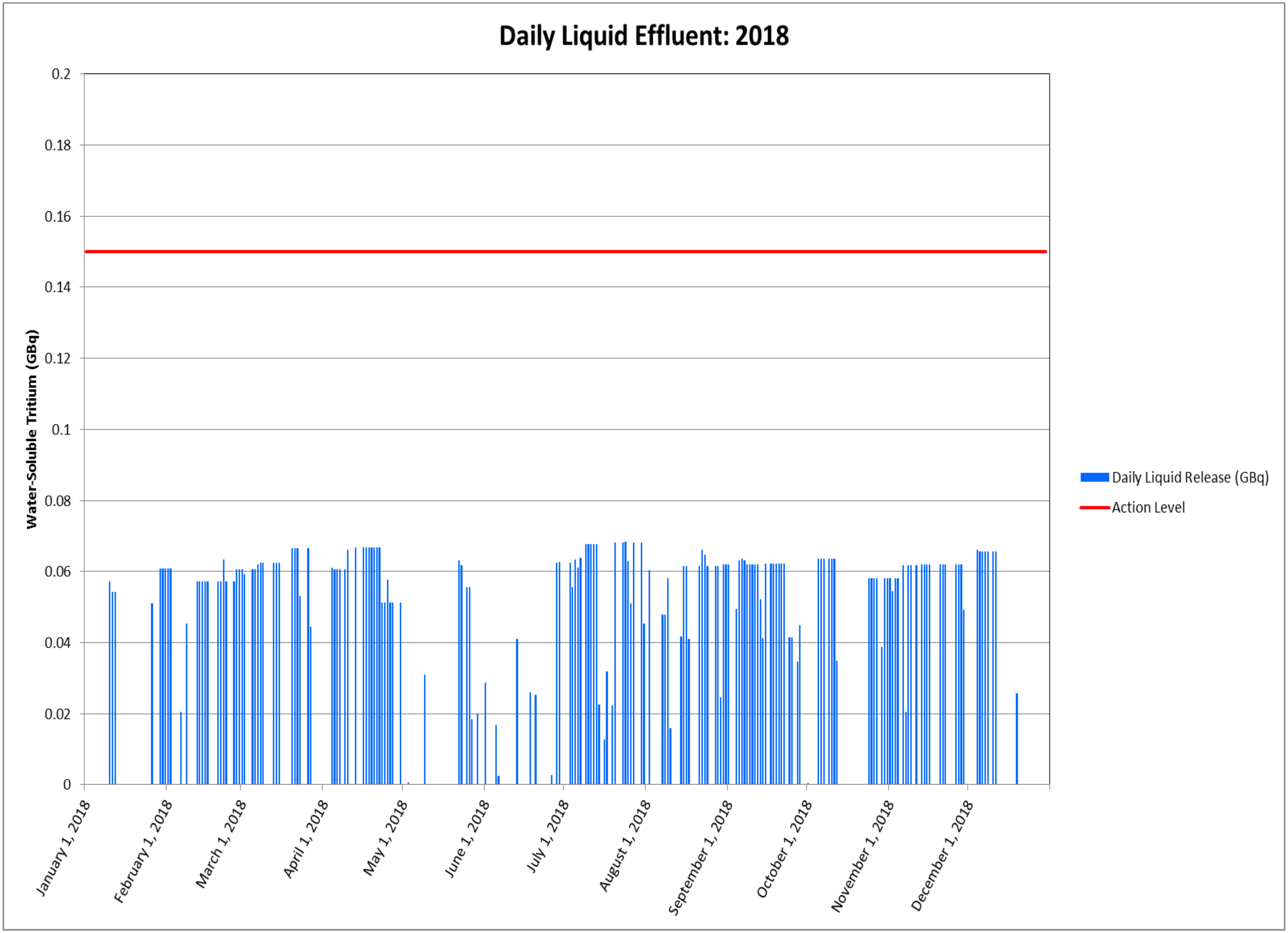

Weekly Gaseous Effluent: Total Tritium 2018
Tritium Released (GBq)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51
Week
HTO
HT
Total Tritium (HTO+HT)
Action Level - Total Tritium

APPENDIX Q

Liquid Effluent Data for 2018

ANNUAL LIQUID EFFLUENT TRACKING TABLE			
Year = 2018			
WEEK ENDING	WEEKLY RELEASE (Bq)	WEEK	ANNUAL LICENCE LIMIT
			200,000,000,000
7-Jan-18	192,640	1	199,999,807,360
14-Jan-18	165,905,308	2	199,833,902,052
21-Jan-18	0	3	199,833,902,052
28-Jan-18	51,094,040	4	199,782,808,012
4-Feb-18	304,708,050	5	199,478,099,962
11-Feb-18	65,876,770	6	199,412,223,192
18-Feb-18	286,291,800	7	199,125,931,392
25-Feb-18	235,071,973	8	198,890,859,419
4-Mar-18	298,570,668	9	198,592,288,751
11-Mar-18	308,338,142	10	198,283,950,609
18-Mar-18	187,608,078	11	198,096,342,531
25-Mar-18	253,079,276	12	197,843,263,255
1-Apr-18	111,048,680	13	197,732,214,575
8-Apr-18	243,125,226	14	197,489,089,349
15-Apr-18	193,370,017	15	197,295,719,332
22-Apr-18	466,713,702	16	196,829,005,630
29-Apr-18	262,606,994	17	196,566,398,636
6-May-18	51,893,664	18	196,514,504,972
13-May-18	31,087,190	19	196,483,417,782
20-May-18	0	20	196,483,417,782
27-May-18	254,309,100	21	196,229,108,682
3-Jun-18	48,742,233	22	196,180,366,449
10-Jun-18	19,374,200	23	196,160,992,249
17-Jun-18	41,074,733	24	196,119,917,516
24-Jun-18	51,153,867	25	196,068,763,649
1-Jul-18	127,871,740	26	195,940,891,909
8-Jul-18	306,396,370	27	195,634,495,539
15-Jul-18	361,308,096	28	195,273,187,443
22-Jul-18	135,398,693	29	195,137,788,750
29-Jul-18	318,800,530	30	194,818,988,220
5-Aug-18	174,112,160	31	194,644,876,060
12-Aug-18	169,977,913	32	194,474,898,147
19-Aug-18	205,909,851	33	194,268,988,296
26-Aug-18	253,958,563	34	194,015,029,733
2-Sep-18	333,819,038	35	193,681,210,695
9-Sep-18	363,490,219	36	193,317,720,476
16-Sep-18	341,829,161	37	192,975,891,315
23-Sep-18	373,757,166	38	192,602,134,149
30-Sep-18	162,622,249	39	192,439,511,900
7-Oct-18	191,434,200	40	192,248,077,700
14-Oct-18	225,868,060	41	192,022,209,640
21-Oct-18	0	42	192,022,209,640
28-Oct-18	232,348,200	43	191,789,861,440
4-Nov-18	383,688,870	44	191,406,172,570
11-Nov-18	267,485,400	45	191,138,687,170
18-Nov-18	248,031,828	46	190,890,655,342
25-Nov-18	186,023,871	47	190,704,631,471
2-Dec-18	235,360,389	48	190,469,271,082
9-Dec-18	328,908,915	49	190,140,362,167
16-Dec-18	131,434,926	50	190,008,927,241
23-Dec-18	25,724,050	51	189,983,203,191
30-Dec-18	0	52	189,983,203,191
		53	189,983,203,191
Annual Total (Bq)	10,016,796,809		
Annual Total (GBq)	10.02		
Limit (GBq)	200		
% of limit	**5.01**		

APPENDIX Q



Daily Liquid Effluent: 2018
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Water-Soluble Tritium (GBq)
January 1, 2018
February 1, 2018
March 1, 2018
April 1, 2018
May 1, 2018
June 1, 2018
July 1, 2018
August 1, 2018
September 1, 2018
October 1, 2018
November 1, 2018
December 1, 2018
Daily Liquid Release (GBq)
Action Level

APPENDIX R

Compilation of Water Level Measurements for 2018

Groundwater Well Level Measurement Summary 2018

	MW06-1	MW06-2	MW06-3	MW06-8	MW06-9	MW06-10	MW07-11	MW07-12	MW07-13	MW07-15	MW07-16	MW07-17	MW07-18	MW07-19
Easting	335449	335478	335363	335464	335401	335408	335478	335465	335448	335403	335393	335392	335387	335378
Northing	5074615	5074578	5074535	5074590	5074605	5074506	5074576	5074588	5074616	5074605	5074599	5074599	5074595	5074587
TOP Elevation (m)	130.99	130.03	133.09	130.30	131.15	131.32	130.06	130.41	130.92	130.84	130.98	131.08	131.23	131.61
GS Elevation (m)	130.17	129.24	132.32	129.58	129.86	130.24	129.15	129.58	130.03	129.93	130.16	130.16	130.37	130.79
Well Diameter (m)	0.051	0.051	0.051	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.051	0.032	0.032
Well Depth (m)	5.165	5.330	6.130	6.700	5.930	7.770	7.215	7.450	6.615	7.230	7.050	14.610	7.250	7.400
Stick-up (m)	0.820	0.788	0.767	0.720	1.290	1.077	0.905	0.835	0.893	0.910	0.822	0.915	0.868	0.815
dd/mm/yy														
03-Jan-18	127.65	127.13	127.54	126.25	127.48	124.92	125.30	126.26	126.07	126.89	126.82	122.28	126.85	124.95
31-Jan-18	127.47	126.98	127.34	126.04	127.31	126.77	126.11	126.01	125.77	126.60	126.52	121.43	126.55	126.64
28-Feb-18	128.40	127.02	129.03	126.72	127.74	127.93	126.78	126.71	126.84	127.92	127.83	121.97	127.98	128.12
03-Apr-18	128.80	127.30	130.11	127.46	128.87	128.95	127.48	127.43	127.46	128.78	128.72	123.31	128.98	129.15
02-May-18	129.08	128.17	130.27	128.13	129.71	129.47	128.15	128.17	128.11	129.40	129.40	124.83	129.56	129.68
30-May-18	128.78	127.71	128.65	127.37	129.00	128.39	127.40	127.37	128.27	128.41	128.35	122.99	128.39	128.48
28-Jun-18	128.34	127.48	127.76	126.66	128.12	127.69	126.72	126.65	126.50	127.48	127.39	122.24	127.43	127.51
31-Jul-18	128.08	127.27	127.02	126.06	127.33	126.72	126.15	126.02	125.88	126.77	126.58	120.93	126.53	126.63
04-Sep-18	127.28	127.03	127.03	125.78	126.93	126.25	125.90	125.70	125.36	126.17	126.08	120.68	126.10	126.13
01-Oct-18	127.91	127.07	127.05	126.08	127.40	127.14	126.21	126.08	125.89	126.74	126.63	120.74	126.58	126.59
01-Nov-18	126.96	127.10	127.03	125.94	126.76	126.64	126.08	125.93	125.70	126.63	126.50	120.54	126.42	124.95
03-Dec-18	128.69	127.90	129.09	127.08	128.37	128.06	127.13	127.03	126.92	128.08	127.99	121.55	127.98	128.08

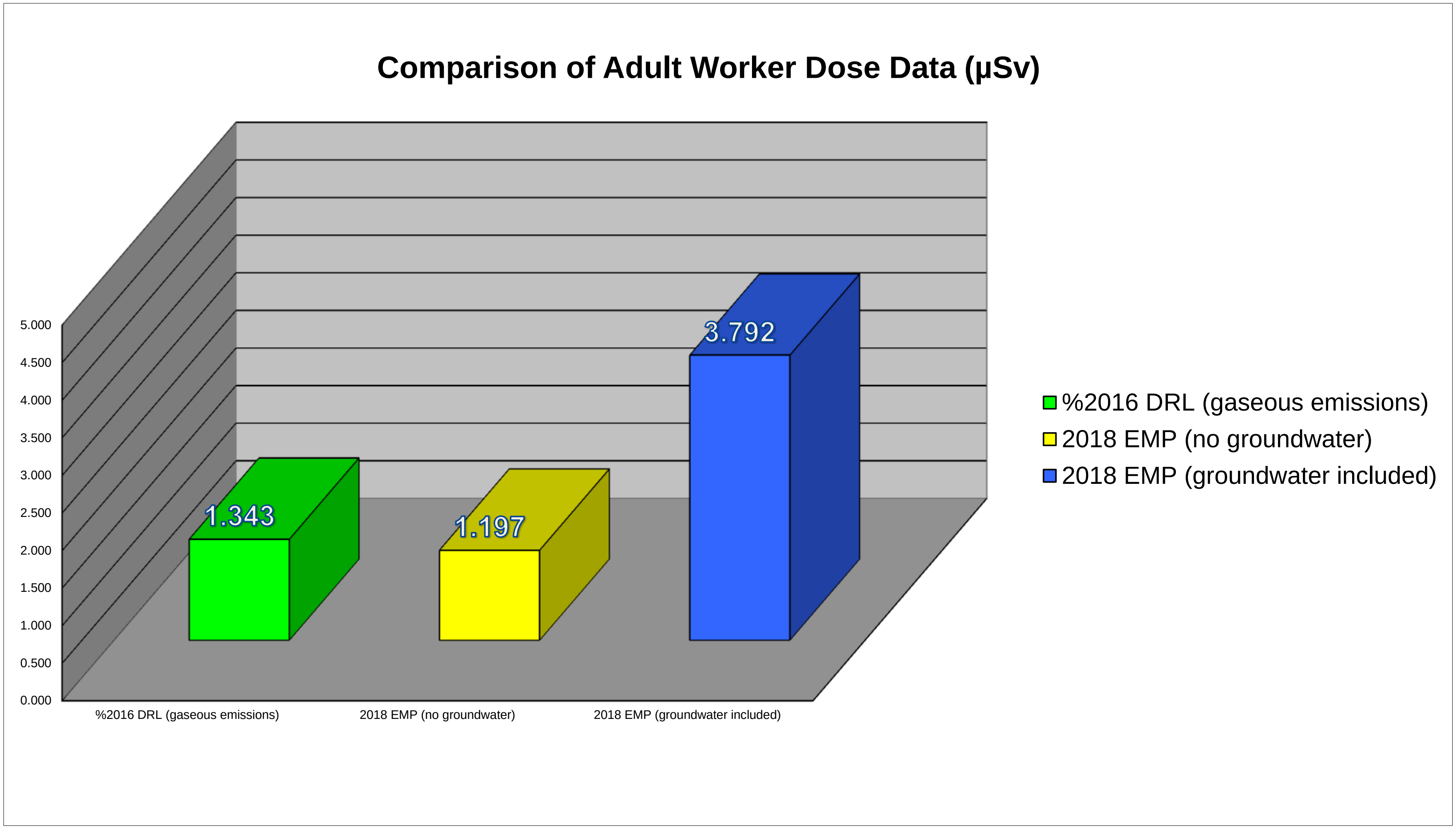
	MW07-20	MW07-21	MW07-22	MW07-23	MW07-24	MW07-26	MW07-27	MW07-28	MW07-29	MW07-31	MW07-32	MW07-34	MW07-35	MW07-36	MW07-37
Easting	335296	335522	335472	335492	335519	335357	335354	335352	335384	335471	335517	335393	335354	335338	335468
Northing	5074616	5074584	5074584	5074560	5074530	5074567	5074611	5074612	5074592	5074583	5074530	5074591	5074613	5074629	5074589
TOP Elevation (m)	130.70	129.51	130.25	130.04	129.03	132.42	132.89	132.71	131.09	130.16	128.86	131.12	132.89	133.10	130.06
GS Elevation (m)	129.85	128.78	129.05	129.29	128.22	131.85	132.02	132.04	130.57	129.38	128.23	130.71	132.16	132.31	129.47
Well Diameter (m)	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
Well Depth (m)	7.820	7.580	7.465	5.905	6.525	7.310	8.330	14.400	13.000	13.240	13.090	9.110	9.390	9.330	8.590
Stick-up (m)	0.850	0.730	1.200	0.750	0.810	0.570	0.870	0.670	0.520	0.780	0.630	0.410	0.730	0.790	0.590
dd/mm/yy															
03-Jan-18	125.40	124.54	126.11	126.80	126.10	126.26	126.29	122.24	122.23	121.43	121.42	126.08	125.95	125.02	126.32
31-Jan-18	124.91	124.21	125.90	126.76	125.94	126.65	125.94	122.52	121.54	120.17	120.16	125.78	125.62	124.86	126.13
28-Feb-18	126.09	125.53	126.63	127.00	126.30	128.68	127.72	122.11	122.13	120.71	120.70	127.16	127.30	126.41	126.89
03-Apr-18	126.96	126.19	127.36	127.74	127.02	129.91	128.91	123.31	123.29	122.95	122.94	128.10	128.40	127.22	127.58
02-May-18	127.70	127.19	128.05	128.33	127.41	130.18	129.67	124.56	124.56	124.68	124.69	128.82	129.25	128.30	128.28
30-May-18	126.52	125.74	127.26	127.77	126.83	128.61	128.14	123.03	128.08	121.49	121.48	127.61	127.75	126.68	127.48
28-Jun-18	125.63	124.57	126.53	127.35	126.30	127.54	127.84	122.30	122.31	120.79	120.81	126.52	126.51	125.33	126.77
31-Jul-18	124.44	123.67	125.93	126.79	125.86	126.23	125.84	121.04	121.07	119.60	119.52	125.75	125.52	124.86	126.14
04-Sep-18	124.34	123.61	125.66	126.52	125.68	125.89	125.37	120.72	120.73	119.55	119.56	125.30	125.10	124.62	125.89
01-Oct-18	124.78	124.23	125.98	126.79	125.98	126.16	125.74	120.81	120.83	119.55	119.56	125.63	125.44	124.90	126.21
01-Nov-18	124.42	123.73	125.84	126.74	125.97	125.94	125.51	120.59	120.63	119.49	119.49	125.59	125.26	124.74	126.06
03-Dec-18	125.95	125.31	126.93	127.79	126.87	128.16	127.02	121.64	121.66	120.24	120.23	126.89	126.59	125.52	127.15

APPENDIX S

Data and Calculations for Public Dose in 2018

ADULT WORKER

Dose Calculation	2018 µSv
%2016 DRL (gaseous emissions)	1.343
2018 EMP (no groundwater)	1.197
2018 EMP (groundwater included)	3.792



ADULT WORKER

Stack Emissions

	2018 Emissions as %2016 SRBT DRL	
	ADULT WORKER	
Sample End	**% weekly DRL**	**(uSv)**
02/01/2018	0.01	0.0027
09/01/2018	0.03	0.0066
16/01/2018	0.09	0.0168
23/01/2018	0.10	0.0186
30/01/2018	0.07	0.0143
06/02/2018	0.09	0.0166
13/02/2018	0.06	0.0107
20/02/2018	0.04	0.0071
27/02/2018	0.05	0.0089
06/03/2018	0.04	0.0074
13/03/2018	0.05	0.0094
20/03/2018	0.09	0.0166
27/03/2018	0.08	0.0158
03/04/2018	0.07	0.0135
10/04/2018	0.09	0.0164
17/04/2018	0.07	0.0143
24/04/2018	0.13	0.0249
01/05/2018	0.14	0.0263
08/05/2018	0.11	0.0219
15/05/2018	0.09	0.0170
22/05/2018	0.01	0.0022
29/05/2018	0.15	0.0292
05/06/2018	0.28	0.0531
12/06/2018	0.20	0.0377
19/06/2018	0.22	0.0421
26/06/2018	0.20	0.0388
03/07/2018	0.17	0.0336
10/07/2018	0.23	0.0449
17/07/2018	0.19	0.0360
24/07/2018	0.18	0.0339
31/07/2018	0.23	0.0449
07/08/2018	0.14	0.0275
14/08/2018	0.32	0.0614
21/08/2018	0.29	0.0552
28/08/2018	0.23	0.0450
04/09/2018	0.18	0.0347
11/09/2018	0.17	0.0336
18/09/2018	0.22	0.0430
25/09/2018	0.24	0.0463
02/10/2018	0.12	0.0233
09/10/2018	0.13	0.0256
16/10/2018	0.14	0.0272
23/10/2018	0.13	0.0257
30/10/2018	0.13	0.0251
06/11/2018	0.09	0.0175
13/11/2018	0.19	0.0357
20/11/2018	0.13	0.0258
27/11/2018	0.09	0.0177
04/12/2018	0.13	0.0253
11/12/2018	0.09	0.0177
18/12/2018	0.15	0.0295
25/12/2018	0.09	0.0180
Sum (uSv)		**1.343**
Ave. (%DRL)	**0.13**	
Annual Dose Est.	**1.343 uSv/a**	

ADULT WORKER

ADULT WORKER
EMP Factors for Dose

Pathways Analysis of Dose to the Public			
		per annum	
Atmospheric HTO inhalation, immersion	P(i)19, P(e)19	0.747	
Surface HTO ingestion	P(i)29	2.595	
Surface HTO immersion	P(e)29	0.000	
External soil exposure	P39	0.000	
Forage & crop ingestion	P49	0.436	
Animal produce ingestion	P59	0.014	
Aquatic animal ingestion	P69	0.000	
Aquatic plant ingestion	P79	0.000	
External sediment exposure	P89	0.000	
Total	**(uSv)**	**3.792**	**uSv/a**
Total without P_{29}	**(uSv)**	**1.197**	**uSv/a**

ADULT WORKER
EMP Factors for Dose P19

P19 is the transfer pathway of exposure to HTO from compartment 1 (Atmosphere) to 9 (dose)
P(i)19 is the pathway of exposure due to inhalation of HTO, and also implicitly captures skin absorption dose P(e)19 as per CSA N288.1-14 Table C.1.

Formula:
P(i)19 (uSv) = [HTO]air (Bq/m3) x Inhalation (m3) x DCF (uSv/Bq)

Calculation:

PAS # (#)	P(i)19 (uSv)	[HTO]air (Bq/m^3)	Volume (m^3)	(uSv/Bq)	(uSv/a)	(uSv/a)	(uSv/a)	Maximum (uSv/a)
1	0.274	4.580	1994.496	3.000E-05	0.274			
2	0.259	4.330	1994.496	3.000E-05		0.259		
3	0.000			3.000E-05				
4	0.473	2.460	6405.504	3.000E-05	0.473	0.473	0.473	
5	0.000			3.000E-05				
6	0.000			3.000E-05				
7	0.000			3.000E-05				
8	0.000			3.000E-05				
9	0.000			3.000E-05				
10	0.000			3.000E-05				
11	0.000			3.000E-05				
12	0.000			3.000E-05				
13	0.194	3.240	1994.496	3.000E-05			0.194	
			P(i)19	**Sum**	**0.747**	**0.732**	**0.667**	**0.747** uSv/a

ADULT WORKER
EMP Factors for Dose P29

P29 is the transfer pathway of exposure to HTO from compartment 2 (Surface Water) to 9 (Dose)
P(i)29 is the pathway of exposure due to ingestion of HTO
P(e)29 is the pathway of exposure due to immersion in HTO

Formula:
P(i)29 = [HTO] (Bq/L) x Ingestion (L) x DCF (uSv/Bq)

Well	P(i)29 (uSv/a)	[HTO]well (Bq/L)	Ingestion (L/a)	DCF (uSv/Bq)
1	0.000	0	1081.1	2.00E-05
2	0.966	45	1081.1	2.00E-05
3	1.189	55	1081.1	2.00E-05
4	0.000	0	1081.1	2.00E-05
5	0.130	6	1081.1	2.00E-05
6	0.137	6	1081.1	2.00E-05
7	0.072	3	1081.1	2.00E-05
8	2.595	120	1081.1	2.00E-05
9	0.000	0	1081.1	2.00E-05
10	0.000	0	1081.1	2.00E-05
11	0.000	0	1081.1	2.00E-05
12	0.000	0	1081.1	2.00E-05
Avg P(i)29	**0.424**	**uSv/annum**		

Date	Well 1 (Bq/L)	Well 2 (Bq/L)	Well 3 (Bq/L)	Well 4 (Bq/L)	Well 5 (Bq/L)	Well 6 (Bq/L)	Well 7 (Bq/L)	Well 8 (Bq/L)	Well 9 (Bq/L)	Well 10 (Bq/L)	Well 11 (Bq/L)	Well 12 (Bq/L)
Jan. 4, 2018												
Feb. 1, 2018												
Mar. 1, 2018		47	53		6	6	4	120				
Apr. 4, 2018												
May 3, 2018												
Jun. 1, 2018												
Jun. 29, 2018		48	55		7	6	3					
Aug. 1, 2018												
Sep. 5, 2018												
Oct. 2, 2018												
Nov. 2, 2018		39	57		5	7	3					
Dec. 4, 2018												
Average		**45**	**55**		**6**	**6**	**3**	**120**				

Well 1	*No longer sampled*
Well 2	185 Mud Lake Road
Well 3	183 Mud Lake Road
Well 4	*No longer sampled*
Well 5	171 Sawmill Road
Well 6	40987 Highway 41
Well 7	40925 Highway 41
Well 8	*No longer sampled*
Well 9	*No longer sampled*
Well 10	*No longer sampled*
Well 11	*No longer sampled*
Well 12	*No longer sampled*

P(e)29 is the pathway of exposure to HTO due to immersion in surface water.
P(e)29 is considered negligible as surface waters throughout 2018 were measured as <detectable.

P(e)29 = 0.000 uSv/a

RW-8	**P(i)29**	**2.595**	**uSv/a**
	P(e)29	**0.000**	**uSv/a**
	P29	**2.595**	**uSv/a**

ADULT WORKER
EMP Factors for Dose P49

P49 is the pathway for exposure to HTO due to ingestion of forage and crops.

Produce Sample Results (Bq free water tritium / kg fresh weight)																	
Source	**Market**				**Home**												
Type	**Onion**	**Cucumber**	**Pumpkin**	**Average**	**LOCATION**	**Beet**	**Green Pepper**	**Rhubarb Leaf**	**Carrot**	**Apple**	**Tomato**	**Potato**	**Cucumber**	**Swiss Chard**	**Onion**	**Zucchini**	**Average**
	4.00	4.00	4.00	4.0	413 SWEEZEY COURT	118.00			91.00	91.00			105.00				101.3
					406 BOUNDARY ROAD					85.00							85.0
					408 BOUNDARY ROAD						74.00		75.00		62.00		70.3
					611 MOSS DRIVE						72.00		210.00				141.0
					416 BOUNDARY ROAD					87.00							87.0
Average	4.00	4.00	4.00	4.0		118.00			91.00	87.67	73.00		130.00		62.00		96.9

Produce Sample Results (Bq organically bound tritium / kg fresh weight)							
Comm.			3.00	3.0	408 BOUNDARY ROAD	4.00 (Tomato)	4.0

Produce Consumption						
100%=	**413.300**	**kg/a**	**[HTO] (Bq/kg)**	**(Bq/a)**	**[OBT] (Bq/kg)**	**(Bq/a)**
70%	289.310	**kg/a**	4.0	1157.24	3.0	867.93
30%	123.990	**kg/a**	141.0	17482.59	4.0	495.96

P49 = [HTO or OBT]produce (Bq/kg) x Produce Ingested (kg/mo) x DCF (uSv/Bq)

P49 (uSv/a)	**[HTO] pro (Bq/a)**	**DCF (uSv/Bq)**	**[OBT] pro (Bq/a)**	**DCF (uSv/Bq)**
0.436	**18639.83**	2.00E-05	**1363.89**	4.60E-05

P49	**0.436**	**uSv/a**

ADULT WORKER
EMP Factors for Dose P59

P59 is the exposure to HTO due to ingestion of animal produce.

2018 Sample Results

Local Producer	
	(Bq/L)
1	3.60
2	3.50
3	4.00
Average	**3.70**

Local Distributor	
	(Bq/L)
1	4.00
2	4.00
3	4.00
Average	**4.00**

TOTAL AVERAGE	**3.85**	Bq/L

Milk Density Adjustment		
Milk Average (Bq/L) x Milk density (L/kg)		
Bq/L	**L/kg**	**Bq/kg**
3.85	0.97	**3.735**

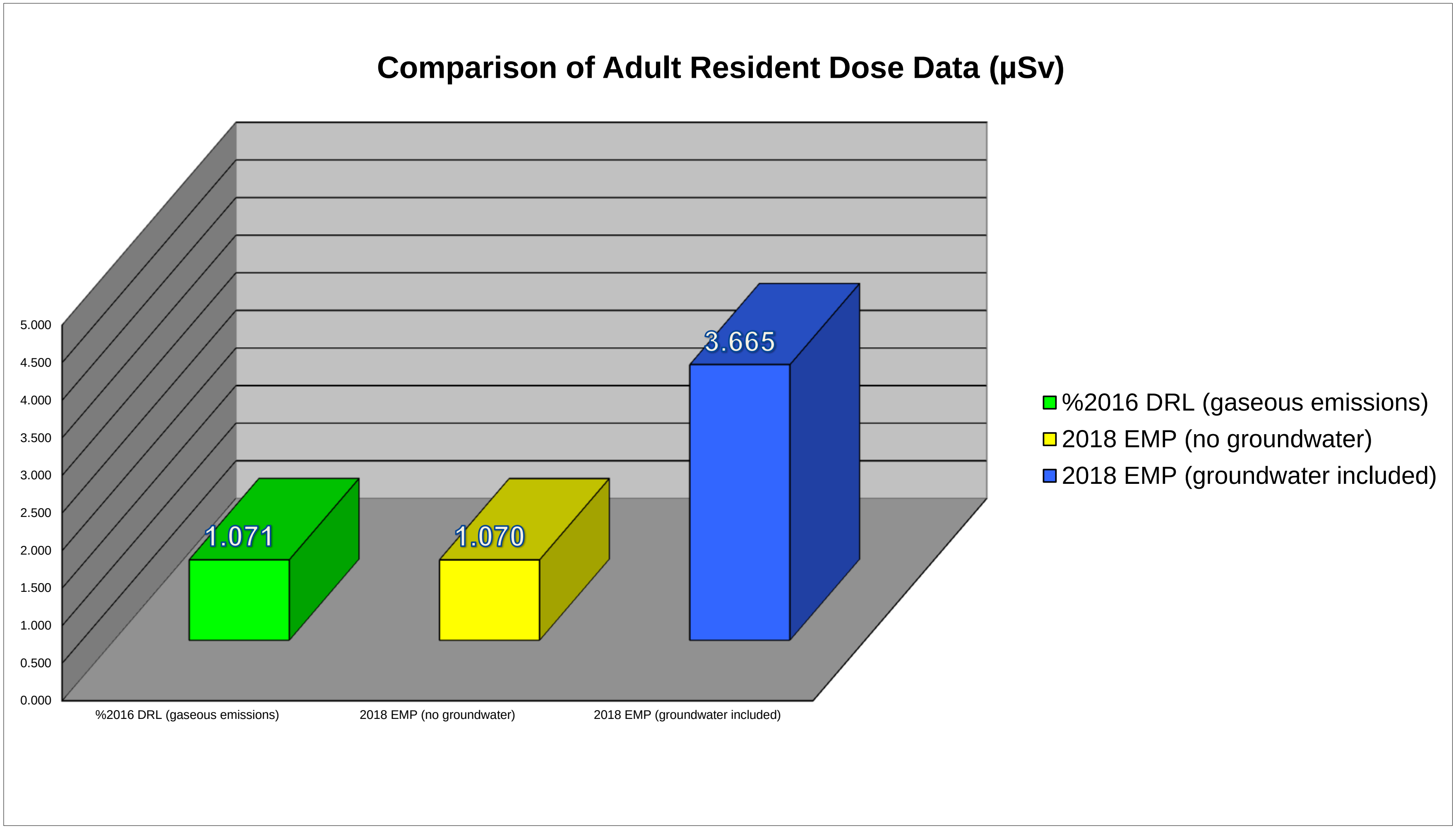
Consumption kg/da x da/a = kg/a		
(kg/da)	**(da/a)**	**(kg/a)**
0.516	365.25	**188.5**

P59 = [HTO]animal produce (Bq/kg) x Ingestion (kg) x DCF				
P59	**[HTO]**	**Ingested**	**DCF**	
(uSv/a)	**(Bq/kg)**	**(kg/a)**	**(uSv/Bq)**	
0.014	**3.73**	**188.5**	2.00E-05	

P59	**0.014**	**uSv/a**

ADULT RESIDENT

Dose Calculation	2018 µSv
%2016 DRL (gaseous emissions)	1.071
2018 EMP (no groundwater)	1.070
2018 EMP (groundwater included)	3.665



ADULT RESIDENT

Stack Emissions

	2018 Emissions as %2016 SRBT DRL	
	ADULT RESIDENT	
Sample End	% weekly DRL	(uSv)
02/01/2018	0.01	0.0022
09/01/2018	0.03	0.0053
16/01/2018	0.07	0.0135
23/01/2018	0.08	0.0151
30/01/2018	0.06	0.0114
06/02/2018	0.08	0.0148
13/02/2018	0.05	0.0088
20/02/2018	0.03	0.0057
27/02/2018	0.04	0.0072
06/03/2018	0.03	0.0060
13/03/2018	0.04	0.0075
20/03/2018	0.07	0.0134
27/03/2018	0.07	0.0126
03/04/2018	0.06	0.0108
10/04/2018	0.07	0.0130
17/04/2018	0.06	0.0113
24/04/2018	0.10	0.0198
01/05/2018	0.11	0.0208
08/05/2018	0.09	0.0174
15/05/2018	0.07	0.0134
22/05/2018	0.01	0.0017
29/05/2018	0.12	0.0231
05/06/2018	0.22	0.0420
12/06/2018	0.16	0.0300
19/06/2018	0.17	0.0333
26/06/2018	0.16	0.0308
03/07/2018	0.14	0.0266
10/07/2018	0.18	0.0356
17/07/2018	0.15	0.0285
24/07/2018	0.14	0.0269
31/07/2018	0.18	0.0354
07/08/2018	0.11	0.0218
14/08/2018	0.25	0.0486
21/08/2018	0.23	0.0437
28/08/2018	0.19	0.0359
04/09/2018	0.15	0.0279
11/09/2018	0.14	0.0266
18/09/2018	0.18	0.0355
25/09/2018	0.19	0.0372
02/10/2018	0.10	0.0185
09/10/2018	0.11	0.0207
16/10/2018	0.11	0.0217
23/10/2018	0.11	0.0205
30/10/2018	0.10	0.0200
06/11/2018	0.07	0.0139
13/11/2018	0.15	0.0282
20/11/2018	0.11	0.0204
27/11/2018	0.07	0.0140
04/12/2018	0.10	0.0200
11/12/2018	0.07	0.0140
18/12/2018	0.12	0.0238
25/12/2018	0.07	0.0142
Sum (uSv)		**1.071**
Ave. (%DRL)	**0.11**	
Annual Dose Est.	**1.071 uSv/a**	

Adult Resident

ADULT RESIDENT
EMP Factors for Dose

Pathways Analysis of Dose to the Public		
		per annum
Atmospheric HTO inhalation, immersion	P(i)19, P(e)19	0.620
Surface HTO ingestion	P(i)29	2.595
Surface HTO immersion	P(e)29	0.000
External soil exposure	P39	0.000
Forage & crop ingestion	P49	0.436
Animal produce ingestion	P59	0.014
Aquatic animal ingestion	P69	0.000
Aquatic plant ingestion	P79	0.000
External sediment exposure	P89	0.000
Total (uSv)		**3.665 uSv/a**
Total without P_{29} (uSv)		**1.070 uSv/a**

ADULT RESIDENT
EMP Factors for Dose P19

P19 is the transfer pathway of exposure to HTO from compartment 1 (Atmosphere) to 9 (dose)
P(i)19 is the pathway of exposure due to inhalation of HTO, and also implicitly captures skin absorption dose P(e)19 as per CSA N288.1-14 Table C.1.

Formula:
P(i)19 (uSv) = [HTO]air (Bq/m3) x Inhalation (m3) x DCF (uSv/Bq)

Calculation:

PAS # (#)	P(i)19 (uSv)	[HTO]air (Bq/m^3)	Volume (m^3)	DCF (uSv/Bq)	Sum1,4 (uSv/a)	Sum 2,4 (uSv/a)	Sum 13,4 (uSv/a)	Maximum (uSv/a)
1	0.000			3.000E-05				
2	0.000			3.000E-05				
3	0.000			3.000E-05				
4	0.620	2.460	8400.000	3.000E-05	0.620	0.620	0.620	
5	0.000			3.000E-05				
6	0.000			3.000E-05				
7	0.000			3.000E-05				
8	0.000			3.000E-05				
9	0.000			3.000E-05				
10	0.000			3.000E-05				
11	0.000			3.000E-05				
12	0.000			3.000E-05				
13	0.000			3.000E-05				
			P(i)19	**Sum**	**0.620**	**0.620**	**0.620**	**0.620** uSv/a

ADULT RESIDENT
EMP Factors for Dose P29

P29 is the transfer pathway of exposure to HTO from compartment 2 (Surface Water) to 9 (Dose)
P(i)29 is the pathway of exposure due to ingestion of HTO
P(e)29 is the pathway of exposure due to immersion in HTO

Formula:
P(i)29 = [HTO] (Bq/L) x Ingestion (L) x DCF (uSv/Bq)

Well	P(i)29 (uSv/a)	[HTO]well (Bq/L)	Ingestion (L/a)	DCF (uSv/Bq)
1	0.000	0	1081.1	2.00E-05
2	0.966	45	1081.1	2.00E-05
3	1.189	55	1081.1	2.00E-05
4	0.000	0	1081.1	2.00E-05
5	0.130	6	1081.1	2.00E-05
6	0.137	6	1081.1	2.00E-05
7	0.072	3	1081.1	2.00E-05
8	2.595	120	1081.1	2.00E-05
9	0.000	0	1081.1	2.00E-05
10	0.000	0	1081.1	2.00E-05
11	0.000	0	1081.1	2.00E-05
12	0.000	0	1081.1	2.00E-05
Avg P(i)29	**0.424**	**uSv/annum**		

Date	Well 1 (Bq/L)	Well 2 (Bq/L)	Well 3 (Bq/L)	Well 4 (Bq/L)	Well 5 (Bq/L)	Well 6 (Bq/L)	Well 7 (Bq/L)	Well 8 (Bq/L)	Well 9 (Bq/L)	Well 10 (Bq/L)	Well 11 (Bq/L)	Well 12 (Bq/L)
Jan. 4, 2018												
Feb. 1, 2018												
Mar. 1, 2018		47	53		6	6	4	120				
Apr. 4, 2018												
May 3, 2018												
Jun. 1, 2018												
Jun. 29, 2018		48	55		7	6	3					
Aug. 1, 2018												
Sep. 5, 2018												
Oct. 2, 2018												
Nov. 2, 2018		39	57		5	7	3					
Dec. 4, 2018												
Average		**45**	**55**		**6**	**6**	**3**	**120**				

Well 1	*No longer sampled*
Well 2	185 Mud Lake Road
Well 3	183 Mud Lake Road
Well 4	*No longer sampled*
Well 5	171 Sawmill Road
Well 6	40987 Highway 41
Well 7	40925 Highway 41
Well 8	*No longer sampled*
Well 9	*No longer sampled*
Well 10	*No longer sampled*
Well 11	*No longer sampled*
Well 12	*No longer sampled*

P(e)29 is the pathway of exposure to HTO due to immersion in surface water.
P(e)29 is considered negligible as surface waters throughout 2018 were measured as <detectable.

RW-8	**P(i)29**	**2.595**	**uSv/a**
	P(e)29	**0.000**	**uSv/a**
	P29	**2.595**	**uSv/a**

P(e)29 = 0.000 uSv/a

ADULT RESIDENT
EMP Factors for Dose P49

P49 is the pathway for exposure to HTO due to ingestion of forage and crops.

Produce Sample Results (Bq free water tritium / kg fresh weight)																	
Source	**Market**				**Home**												
Type	**Onion**	**Cucumber**	**Pumpkin**	**Average**	**LOCATION**	**Beet**	**Green Pepper**	**Rhubarb Leaf**	**Carrot**	**Apple**	**Tomato**	**Potato**	**Cucumber**	**Swiss Chard**	**Onion**	**Zucchini**	**Average**
	4.00	4.00	4.00	4.0	413 SWEEZEY COURT	118.00			91.00	91.00			105.00				101.3
					406 BOUNDARY ROAD					85.00							85.0
					408 BOUNDARY ROAD						74.00		75.00		62.00		70.3
					611 MOSS DRIVE						72.00		210.00				141.0
					416 BOUNDARY ROAD					87.00							87.0
Average	4.00	4.00	4.00	4.0		118.00			91.00	87.67	73.00		130.00		62.00		96.9
Produce Sample Results (Bq organically bound tritium / kg fresh weight)																	
Comm.			3.00	3.0	408 BOUNDARY ROAD						4.00						4.0

Produce Consumption						
100%=	**413.300**	**kg/a**	**[HTO] (Bq/kg)**	**(Bq/a)**	**[OBT] (Bq/kg)**	**(Bq/a)**
70%	289.310	**kg/a**	4.0	1157.24	3.0	867.93
30%	123.990	**kg/a**	141.0	17482.59	4.0	495.96

P49 = [HTO or OBT]produce (Bq/kg) x Produce Ingested (kg/mo) x DCF (uSv/Bq)

P49 (uSv/a)	[HTO] pro (Bq/a)	DCF (uSv/Bq)	[OBT] pro (Bq/a)	DCF (uSv/Bq)
0.436	18639.83	2.00E-05	1363.89	4.60E-05

P49	**0.436**	**uSv/a**

ADULT RESIDENT
EMP Factors for Dose P59

P59 is the exposure to HTO due to ingestion of animal produce.

2018 Sample Results

Local Producer	
	(Bq/L)
1	3.60
2	3.50
3	4.00
Average	3.70

Local Distributor	
	(Bq/L)
1	4.00
2	4.00
3	4.00
Average	4.00

TOTAL AVERAGE	3.85	Bq/L

Milk Density Adjustment Milk Average (Bq/L) x Milk density (L/kg)		
Bq/L	**L/kg**	**Bq/kg**
3.85	0.97	3.735

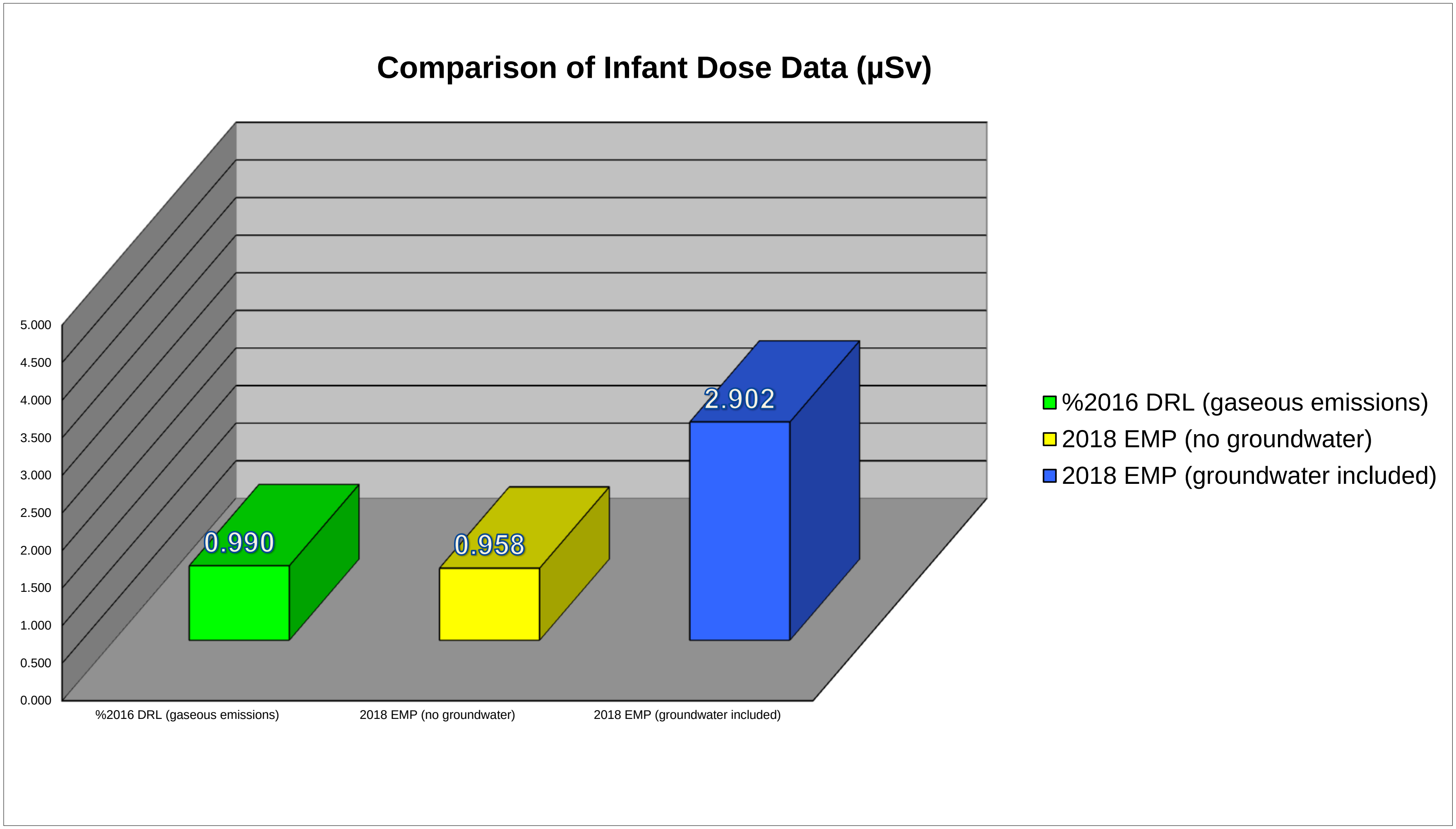
Consumption kg/da x da/a = kg/a		
(kg/da)	**(da/a)**	**(kg/a)**
0.516	365.25	188.5

P59 = [HTO]animal produce (Bq/kg) x Ingestion (kg) x DCF				
P59	**[HTO]**	**Ingested**	**DCF**	
(uSv/a)	**(Bq/kg)**	**(kg/a)**	**(uSv/Bq)**	
0.014	3.73	188.5	2.00E-05	

P59	0.014	uSv/a

INFANT (1 year old child)

Dose Calculation	2018 µSv
%2016 DRL (gaseous emissions)	0.990
2018 EMP (no groundwater)	0.958
2018 EMP (groundwater included)	2.902



INFANT (1 year old child)

Stack Emissions

	2018 Emissions as %2016 SRBT DRL	
	INFANT	
Sample End	**% weekly DRL**	**(uSv)**
02/01/2018	0.01	0.0020
09/01/2018	0.03	0.0049
16/01/2018	0.06	0.0124
23/01/2018	0.07	0.0139
30/01/2018	0.06	0.0106
06/02/2018	0.07	0.0133
13/02/2018	0.04	0.0081
20/02/2018	0.03	0.0052
27/02/2018	0.03	0.0067
06/03/2018	0.03	0.0055
13/03/2018	0.04	0.0069
20/03/2018	0.06	0.0123
27/03/2018	0.06	0.0117
03/04/2018	0.05	0.0100
10/04/2018	0.06	0.0121
17/04/2018	0.05	0.0105
24/04/2018	0.10	0.0183
01/05/2018	0.10	0.0192
08/05/2018	0.08	0.0161
15/05/2018	0.06	0.0124
22/05/2018	0.01	0.0016
29/05/2018	0.11	0.0214
05/06/2018	0.20	0.0389
12/06/2018	0.14	0.0277
19/06/2018	0.16	0.0309
26/06/2018	0.15	0.0285
03/07/2018	0.13	0.0247
10/07/2018	0.17	0.0329
17/07/2018	0.14	0.0264
24/07/2018	0.13	0.0249
31/07/2018	0.17	0.0328
07/08/2018	0.11	0.0202
14/08/2018	0.23	0.0450
21/08/2018	0.21	0.0405
28/08/2018	0.17	0.0332
04/09/2018	0.13	0.0257
11/09/2018	0.13	0.0247
18/09/2018	0.17	0.0325
25/09/2018	0.18	0.0343
02/10/2018	0.09	0.0171
09/10/2018	0.10	0.0191
16/10/2018	0.10	0.0201
23/10/2018	0.10	0.0189
30/10/2018	0.10	0.0185
06/11/2018	0.07	0.0129
13/11/2018	0.14	0.0261
20/11/2018	0.10	0.0189
27/11/2018	0.07	0.0130
04/12/2018	0.10	0.0185
11/12/2018	0.07	0.0130
18/12/2018	0.11	0.0219
25/12/2018	0.07	0.0132
Sum (uSv)		**0.990**
Ave. (%DRL)	**0.10**	
Annual Dose Est.	**0.990 uSv/a**	

INFANT

INFANT (1 year old child)
EMP Factors for Dose

Pathways Analysis of Dose to the Public			
		per annum	
Atmospheric HTO inhalation, immersion	P(i)19, P(e)19	0.539	
Surface HTO ingestion	P(i)29	1.944	
Surface HTO immersion	P(e)29	0.000	
External soil exposure	P39	0.000	
Forage & crop ingestion	P49	0.352	
Animal produce ingestion	P59	0.067	
Aquatic animal ingestion	P69	0.000	
Aquatic plant ingestion	P79	0.000	
External sediment exposure	P89	0.000	
Total	**(uSv)**	**2.902**	**uSv/a**
Total without P_{29}	**(uSv)**	**0.958**	**uSv/a**

INFANT (1 year old child)
EMP Factors for Dose P19

P19 is the transfer pathway of exposure to HTO from compartment 1 (Atmosphere) to 9 (dose)
P(i)19 is the pathway of exposure due to inhalation of HTO, and also implicitly captures skin absorption dose P(e)19 as per CSA N288.1-14 Table C.1.

Formula:
P(i)19 (uSv) = [HTO]air (Bq/m3) x Inhalation (m3) x DCF (uSv/Bq)

Calculation:

PAS # (#)	P(i)19 (uSv)	[HTO]air (Bq/m^3)	Volume (m^3)	DCF (uSv/Bq)	Sum1,4 (uSv/a)	Sum 2,4 (uSv/a)	Sum 13,4 (uSv/a)	Maximum (uSv/a)
1	0.000			8.000E-05				
2	0.000			8.000E-05				
3	0.000			8.000E-05				
4	0.539	2.460	2740.000	8.000E-05	0.539	0.539	0.539	
5	0.000			8.000E-05				
6	0.000			8.000E-05				
7	0.000			8.000E-05				
8	0.000			8.000E-05				
9	0.000			8.000E-05				
10	0.000			8.000E-05				
11	0.000			8.000E-05				
12	0.000			8.000E-05				
13	0.000			8.000E-05				
			P(i)19	**Sum**	**0.539**	**0.539**	**0.539**	**0.539 uSv/a**

INFANT (1 year old child)
EMP Factors for Dose P29

P29 is the transfer pathway of exposure to HTO from compartment 2 (Surface Water) to 9 (Dose)
P(i)29 is the pathway of exposure due to ingestion of HTO
P(e)29 is the pathway of exposure due to immersion in HTO

Formula:
P(i)29 = [HTO] (Bq/L) x Ingestion (L) x DCF (uSv/Bq)

Well	P(i)29 (uSv/a)	[HTO]well (Bq/L)	Ingestion (L/a)	DCF (uSv/Bq)
1	0.000	0	305.7	5.30E-05
2	0.724	45	305.7	5.30E-05
3	0.891	55	305.7	5.30E-05
4	0.000	0	305.7	5.30E-05
5	0.097	6	305.7	5.30E-05
6	0.103	6	305.7	5.30E-05
7	0.054	3	305.7	5.30E-05
8	1.944	120	305.7	5.30E-05
9	0.000	0	305.7	5.30E-05
10	0.000	0	305.7	5.30E-05
11	0.000	0	305.7	5.30E-05
12	0.000	0	305.7	5.30E-05
Avg P(i)29	**0.318**	**uSv/annum**		

Date	Well 1 (Bq/L)	Well 2 (Bq/L)	Well 3 (Bq/L)	Well 4 (Bq/L)	Well 5 (Bq/L)	Well 6 (Bq/L)	Well 7 (Bq/L)	Well 8 (Bq/L)	Well 9 (Bq/L)	Well 10 (Bq/L)	Well 11 (Bq/L)	Well 12 (Bq/L)
Jan. 4, 2018												
Feb. 1, 2018												
Mar. 1, 2018		47	53		6	6	4	120				
Apr. 4, 2018												
May 3, 2018												
Jun. 1, 2018												
Jun. 29, 2018		48	55		7	6	3					
Aug. 1, 2018												
Sep. 5, 2018												
Oct. 2, 2018												
Nov. 2, 2018		39	57		5	7	3					
Dec. 4, 2018												
Average		**45**	**55**		**6**	**6**	**3**	**120**				

Well 1	*No longer sampled*
Well 2	185 Mud Lake Road
Well 3	183 Mud Lake Road
Well 4	*No longer sampled*
Well 5	171 Sawmill Road
Well 6	40987 Highway 41
Well 7	40925 Highway 41
Well 8	*No longer sampled*
Well 9	*No longer sampled*
Well 10	*No longer sampled*
Well 11	*No longer sampled*
Well 12	*No longer sampled*

P(e)29 is the pathway of exposure to HTO due to immersion in surface water.
P(e)29 is considered negligible as surface waters throughout 2017 were measured as <detectable.

RW-8	**P(i)29**	**1.944**	**uSv/a**
	P(e)29	**0.000**	**uSv/a**
	P29	**1.944**	**uSv/a**

P(e)29 = 0.000 uSv/a

INFANT (1 year old child)
EMP Factors for Dose P49

P49 is the pathway for exposure to HTO due to ingestion of forage and crops.

Source	Market				Home													
Type	Onion	Cucumber	Pumpkin	Average	LOCATION	Beet	Green Pepper	Rhubarb Leaf	Carrot	Apple	Tomato	Potato	Cucumber	Swiss Chard	Onion	Zucchini	Average
					Produce Sample Results (Bq free water tritium / kg fresh weight)												
	4.00	4.00	4.00	4.0	413 SWEEZEY COURT	118.00			91.00	91.00			105.00				101.3
					406 BOUNDARY ROAD					85.00							85.0
					408 BOUNDARY ROAD						74.00		75.00		62.00		70.3
					611 MOSS DRIVE						72.00		210.00				141.0
					416 BOUNDARY ROAD					87.00							87.0
Average	4.00	4.00	4.00	4.0		118.00			91.00	87.67	73.00		130.00		62.00		96.9
					Produce Sample Results (Bq organically bound tritium / kg fresh weight)												
Comm.			3.00	3.0	408 BOUNDARY ROAD						4.00						4.0

Produce Consumption

100%=	124.800 kg/a	[HTO] (Bq/kg)	(Bq/a)	[OBT] (Bq/kg)	(Bq/a)
70%	87.360 **kg/a**	4.0	349.44	3.0	262.08
30%	37.440 **kg/a**	141.0	5279.04	4.0	149.76

P49 = [HTO or OBT]produce (Bq/kg) x Produce Ingested (kg/mo) x DCF (uSv/Bq)

P49 (uSv/a)	[HTO] pro (Bq/a)	DCF (uSv/Bq)	[OBT] pro (Bq/a)	DCF (uSv/Bq)
0.352	**5628.48**	5.30E-05	**411.84**	1.30E-04

P49	0.352	uSv/a

INFANT (1 year old child)
EMP Factors for Dose P59

P59 is the exposure to HTO due to ingestion of animal produce.

2018 Sample Results

Local Producer	
	(Bq/L)
1	3.60
2	3.50
3	4.00
Average	**3.70**

Local Distributor	
	(Bq/L)
1	4.00
2	4.00
3	4.00
Average	**4.00**

TOTAL AVERAGE	**3.85**	Bq/L

Milk Density Adjustment		
Milk Average (Bq/L) x Milk density (L/kg)		
Bq/L	**L/kg**	**Bq/kg**
3.85	0.97	**3.735**

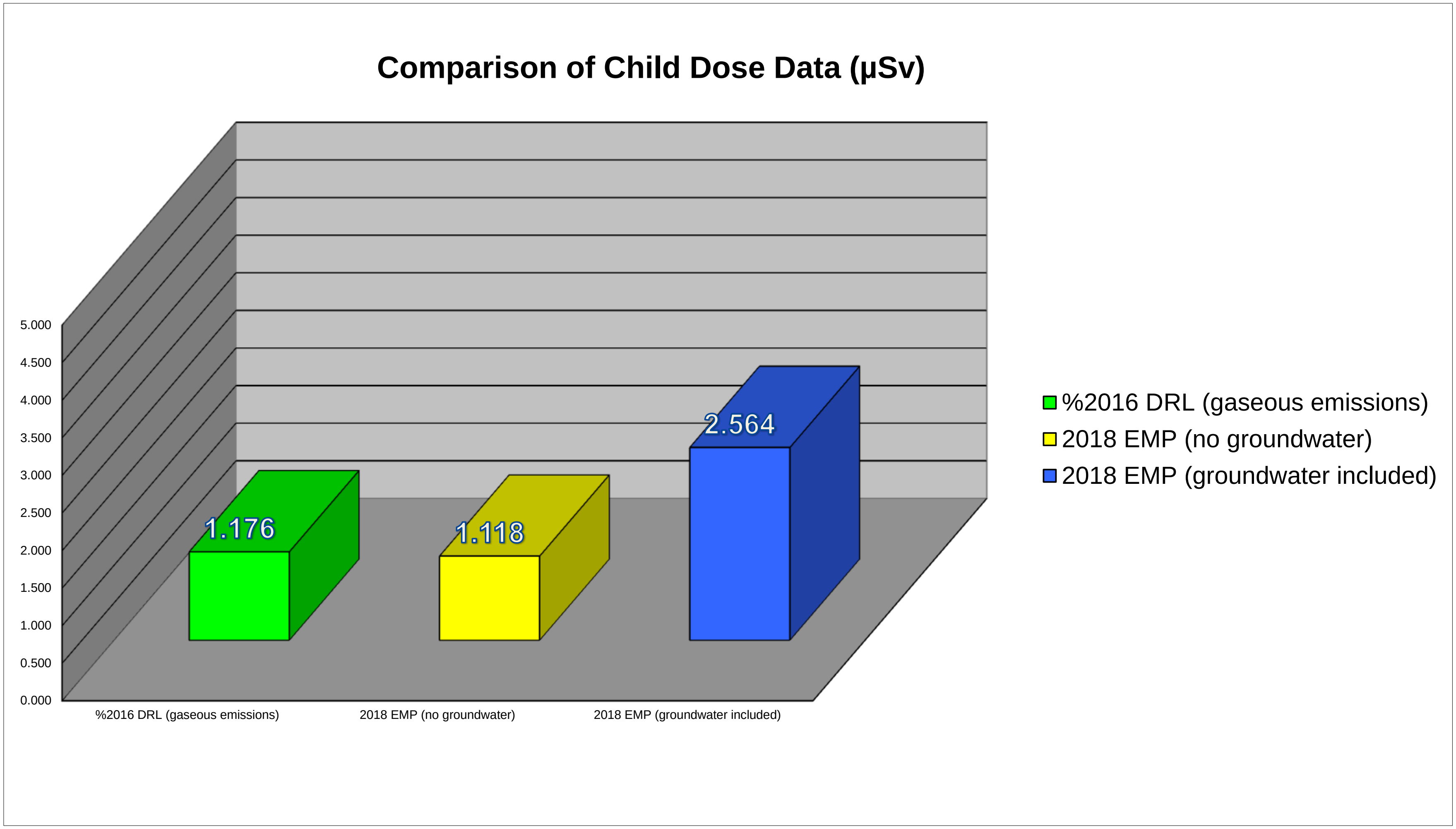
Consumption		
kg/da x da/a = kg/a		
(kg/da)	**(da/a)**	**(kg/a)**
0.931	365.25	**340.0**

P59 = [HTO]animal produce (Bq/kg) x Ingestion (kg) x DCF				
P59	**[HTO]**	**Ingested**	**DCF**	
(uSv/a)	**(Bq/kg)**	**(kg/a)**	**(uSv/Bq)**	
0.067	**3.735**	**340.0**	5.30E-05	

P59	**0.067**	**uSv/a**

CHILD (10 year old child)

Dose Calculation	2018 µSv
%2016 DRL (gaseous emissions)	1.176
2018 EMP (no groundwater)	1.118
2018 EMP (groundwater included)	2.564



CHILD (10 year old child)

Stack Emissions

	2018 Emissions as %2016 SRBT DRL	
	CHILD	
Sample End	**% weekly DRL**	**(uSv)**
02/01/2018	0.01	0.0024
09/01/2018	0.03	0.0058
16/01/2018	0.08	0.0147
23/01/2018	0.09	0.0164
30/01/2018	0.07	0.0126
06/02/2018	0.08	0.0155
13/02/2018	0.05	0.0095
20/02/2018	0.03	0.0062
27/02/2018	0.04	0.0079
06/03/2018	0.03	0.0065
13/03/2018	0.04	0.0082
20/03/2018	0.08	0.0146
27/03/2018	0.07	0.0138
03/04/2018	0.06	0.0118
10/04/2018	0.07	0.0143
17/04/2018	0.06	0.0124
24/04/2018	0.11	0.0218
01/05/2018	0.12	0.0229
08/05/2018	0.10	0.0191
15/05/2018	0.08	0.0148
22/05/2018	0.01	0.0019
29/05/2018	0.13	0.0254
05/06/2018	0.24	0.0463
12/06/2018	0.17	0.0330
19/06/2018	0.19	0.0367
26/06/2018	0.18	0.0339
03/07/2018	0.15	0.0293
10/07/2018	0.20	0.0391
17/07/2018	0.16	0.0314
24/07/2018	0.15	0.0296
31/07/2018	0.20	0.0391
07/08/2018	0.12	0.0240
14/08/2018	0.28	0.0535
21/08/2018	0.25	0.0481
28/08/2018	0.20	0.0394
04/09/2018	0.16	0.0305
11/09/2018	0.15	0.0293
18/09/2018	0.20	0.0384
25/09/2018	0.21	0.0407
02/10/2018	0.11	0.0204
09/10/2018	0.12	0.0226
16/10/2018	0.12	0.0239
23/10/2018	0.12	0.0225
30/10/2018	0.11	0.0219
06/11/2018	0.08	0.0153
13/11/2018	0.16	0.0311
20/11/2018	0.12	0.0225
27/11/2018	0.08	0.0154
04/12/2018	0.11	0.0220
11/12/2018	0.08	0.0154
18/12/2018	0.14	0.0260
25/12/2018	0.08	0.0157
Sum (uSv)		**1.176**
Ave. (%DRL)	**0.12**	
Annual Dose Est.	**1.176 uSv/a**	

CHILD

CHILD (10 year old child)
EMP Factors for Dose

Pathways Analysis of Dose to the Public			
		per annum	
Atmospheric HTO inhalation, immersion	P(i)19, P(e)19	0.734	
Surface HTO ingestion	P(i)29	1.446	
Surface HTO immersion	P(e)29	0.000	
External soil exposure	P39	0.000	
Forage & crop ingestion	P49	0.354	
Animal produce ingestion	P59	0.030	
Aquatic animal ingestion	P69	0.000	
Aquatic plant ingestion	P79	0.000	
External sediment exposure	P89	0.000	
Total	**(uSv)**	**2.564 uSv/a**	
Total without P_{29}	**(uSv)**	**1.118 uSv/a**	

CHILD (10 year old child)
EMP Factors for Dose P19

P19 is the transfer pathway of exposure to HTO from compartment 1 (Atmosphere) to 9 (dose)
P(i)19 is the pathway of exposure due to inhalation of HTO, and also implicitly captures skin absorption dose P(e)19 as per CSA N288.1-14 Table C.1.

Formula:
P(i)19 (uSv) = [HTO]air (Bq/m3) x Inhalation (m3) x DCF (uSv/Bq)

Calculation:

PAS # (#)	P(i)19 (uSv)	[HTO]air (Bq/m^3)	Volume (m^3)	DCF (uSv/Bq)	Sum1,4 (uSv/a)	Sum 2,4 (uSv/a)	Sum 13,4 (uSv/a)	Maximum (uSv/a)	
1	0.000			3.800E-05					
2	0.000			3.800E-05					
3	0.000			3.800E-05					
4	0.734	2.460	7850.000	3.800E-05	0.734	0.734	0.734		
5	0.000			3.800E-05					
6	0.000			3.800E-05					
7	0.000			3.800E-05					
8	0.000			3.800E-05					
9	0.000			3.800E-05					
10	0.000			3.800E-05					
11	0.000			3.800E-05					
12	0.000			3.800E-05					
13	0.000			3.800E-05					
			P(i)19	**Sum**	**0.734**	**0.734**	**0.734**	**0.734**	**uSv/a**

CHILD (10 year old child)
EMP Factors for Dose P29

P29 is the transfer pathway of exposure to HTO from compartment 2 (Surface Water) to 9 (Dose)
P(i)29 is the pathway of exposure due to ingestion of HTO
P(e)29 is the pathway of exposure due to immersion in HTO

Formula:
P(i)29 = [HTO] (Bq/L) x Ingestion (L) x DCF (uSv/Bq)

Well	P(i)29	[HTO]well	Ingestion	DCF	Date	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Well 9	Well 10	Well 11	Well 12
	(uSv/a)	(Bq/L)	(L/a)	(uSv/Bq)		(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)	(Bq/L)
1	0.000	0	482.1	2.50E-05	Jan. 4, 2018												
2	0.538	45	482.1	2.50E-05	Feb. 1, 2018												
3	0.663	55	482.1	2.50E-05	Mar. 1, 2018		47	53		6	6	4	120				
4	0.000	0	482.1	2.50E-05	Apr. 4, 2018												
5	0.072	6	482.1	2.50E-05	May 3, 2018												
6	0.076	6	482.1	2.50E-05	Jun. 1, 2018												
7	0.040	3	482.1	2.50E-05	Jun. 29, 2018		48	55		7	6	3					
8	1.446	120	482.1	2.50E-05	Aug. 1, 2018												
9	0.000	0	482.1	2.50E-05	Sep. 5, 2018												
10	0.000	0	482.1	2.50E-05	Oct. 2, 2018												
11	0.000	0	482.1	2.50E-05	Nov. 2, 2018		39	57		5	7	3					
12	0.000	0	482.1	2.50E-05	Dec. 4, 2018												
Avg P(i)29	**0.236**	**uSv/annum**															
					Average		**45**	**55**		**6**	**6**	**3**	**120**				

Well 1	*No longer sampled*
Well 2	185 Mud Lake Road
Well 3	183 Mud Lake Road
Well 4	*No longer sampled*
Well 5	171 Sawmill Road
Well 6	40987 Highway 41
Well 7	40925 Highway 41
Well 8	*No longer sampled*
Well 9	*No longer sampled*
Well 10	*No longer sampled*
Well 11	*No longer sampled*
Well 12	*No longer sampled*

P(e)29 is the pathway of exposure to HTO due to immersion in surface water.
P(e)29 is considered negligible as surface waters throughout 2017 were measured as <detectable.

RW-8	**P(i)29**	**1.446**	**uSv/a**
	P(e)29	**0.000**	**uSv/a**
	P29	**1.446**	**uSv/a**

P(e)29 = 0.000 uSv/a

CHILD (10 year old child)
EMP Factors for Dose P49

P49 is the pathway for exposure to HTO due to ingestion of forage and crops.

Produce Sample Results (Bq free water tritium / kg fresh weight)																	
Source	**Market**				**Home**												
Type	**Onion**	**Cucumber**	**Pumpkin**	**Average**	**LOCATION**	**Beet**	**Green Pepper**	**Rhubarb Leaf**	**Carrot**	**Apple**	**Tomato**	**Potato**	**Cucumber**	**Swiss Chard**	**Onion**	**Zucchini**	**Average**
	4.00	4.00	4.00	4.0	413 SWEEZEY COURT	118.00			91.00	91.00			105.00				101.3
					406 BOUNDARY ROAD					85.00							85.0
					408 BOUNDARY ROAD						74.00		75.00		62.00		70.3
					611 MOSS DRIVE						72.00		210.00				**141.0**
					416 BOUNDARY ROAD					87.00							87.0
Average	4.00	4.00	4.00	**4.0**		118.00			91.00	87.67	73.00		130.00		62.00		96.9
Produce Sample Results (Bq organically bound tritium / kg fresh weight)																	
Comm.			3.00	**3.0**	408 BOUNDARY ROAD						4.00						**4.0**

Produce Consumption						
100%=	**265.200**	**kg/a**	**[HTO] (Bq/kg)**	**(Bq/a)**	**[OBT] (Bq/kg)**	**(Bq/a)**
70%	185.640	**kg/a**	4.0	742.56	3.0	556.92
30%	79.560	**kg/a**	141.0	11217.96	4.0	318.24

P49 = [HTO or OBT]produce (Bq/kg) x Produce Ingested (kg/mo) x DCF (uSv/Bq)

P49 (uSv/a)	**[HTO] pro (Bq/a)**	**DCF (uSv/Bq)**	**[OBT] pro (Bq/a)**	**DCF (uSv/Bq)**
0.354	**11960.52**	2.50E-05	**875.16**	6.30E-05

P49	**0.354**	**uSv/a**

CHILD (10 year old child)
EMP Factors for Dose P59

P59 is the exposure to HTO due to ingestion of animal produce.

2018 Sample Results

Local Producer	
	(Bq/L)
1	3.60
2	3.50
3	4.00
Average	**3.70**

Local Distributor	
	(Bq/L)
1	4.00
2	4.00
3	4.00
Average	**4.00**

TOTAL AVERAGE	**3.85**	Bq/L

Milk Density Adjustment Milk Average (Bq/L) x Milk density (L/kg)		
Bq/L	**L/kg**	**Bq/kg**
3.85	0.97	**3.735**

Consumption kg/da x da/a = kg/a		
(kg/da)	**(da/a)**	**(kg/a)**
0.875	365.25	**319.6**

P59 = [HTO]animal produce (Bq/kg) x Ingestion (kg) x DCF				
P59	**[HTO]**	**Ingested**	**DCF**	
(uSv/a)	**(Bq/kg)**	**(kg/a)**	**(uSv/Bq)**	
0.030	**3.735**	**319.6**	2.50E-05	

P59	**0.030**	**uSv/a**

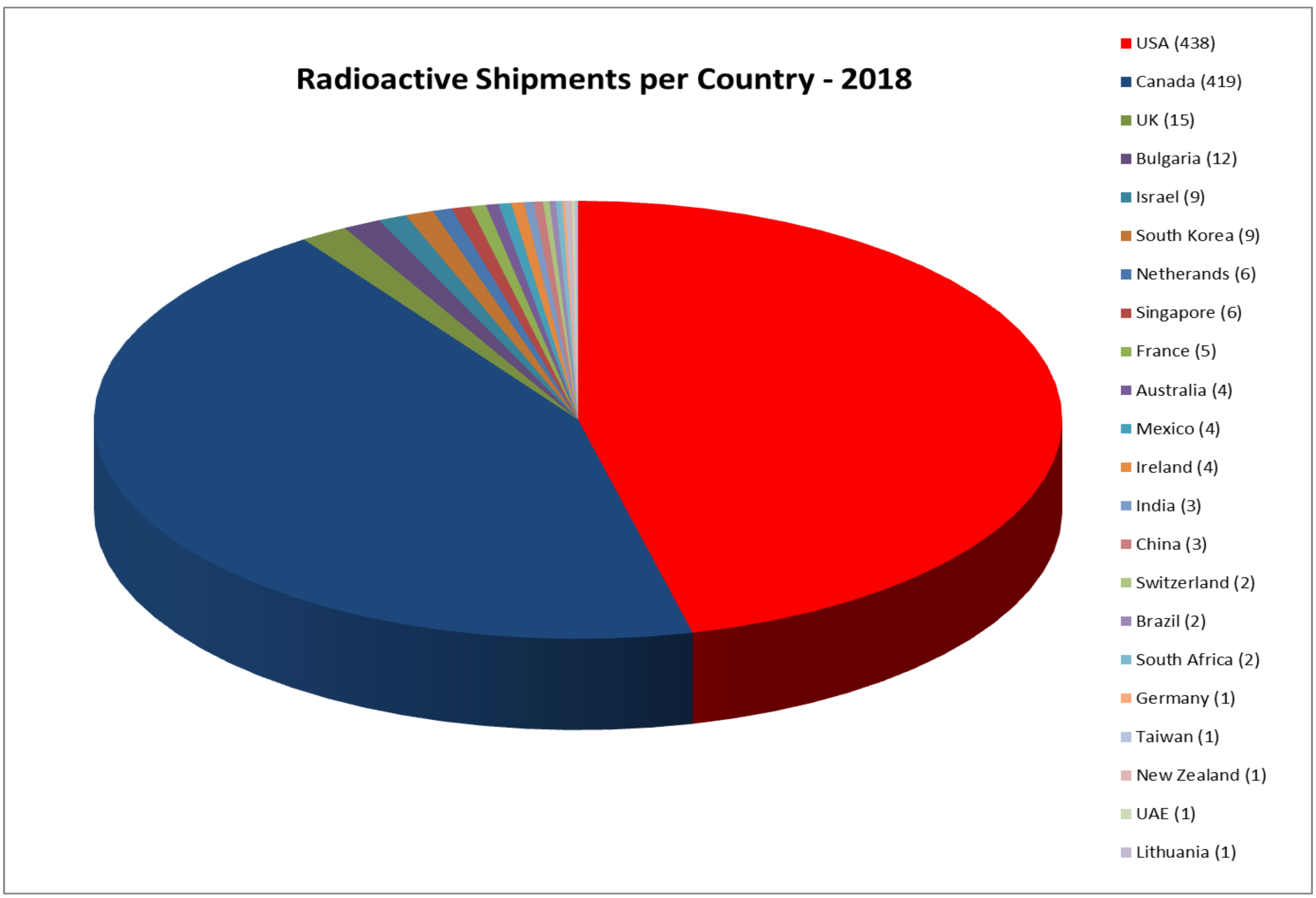
APPENDIX T

Outgoing Shipments Containing Radioactive Material for 2018

SHIPMENTS CONTAINING RADIOACTIVE MATERIAL FOR 2018

Month	Number of Shipments
January	89
February	71
March	84
April	100
May	77
June	85
July	66
August	79
September	86
October	65
November	82
December	64
Total Shipments	**948**
2018 Monthly Average:	79

DISTRIBUTION OF SHIPMENTS CONTAINING RADIOACTIVE MATERIAL FOR 2018



APPENDIX U

Incoming Shipments Containing Radioactive Material for 2018

<u>**INCOMING SHIPMENTS CONTAINING RADIOACTIVE MATERIAL FOR 2018**</u>

Month	**Number of Shipments**
January	53
February	39
March	52
April	35
May	37
June	76
July	46
August	42
September	42
October	40
November	25
December	31
Total Shipments	**518**
2018 Monthly Average:	43

<u>**ORIGIN OF INCOMING SHIPMENTS FOR 2018**</u>