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OLYMPIC DAM

Annual Radiation Protection Report

July 2010 to June 2011

Olympic Dam
BHP Billiton Limited
Uranium CSG
ABN 99 007 835 761

A member of the BHP Billiton Group, which is headquartered in Australia
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ABN 49 004 028 077

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July 2010 June 2011

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This Report has been reviewed by:

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Superintendent Radiation & Occupational Hygiene	Cameron Lawrence

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Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

This document is the annual report on radiation protection for BHP Billiton Olympic Dam Incorporation Pty Ltd.

In fulfilment of clause 2.10.1, 3.8.1 and 3.10.1 of the Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Processing 2005, employee dose assessments, dose calculation methodologies, dose parameters and dose conversion factors for the period 1 July 2010 to 30 June 2011 are presented. Individual personal doses and dose components for the period 1 July 2010 to 30 June 2011 are forwarded with this document on electronic media.

2 EMPLOYEE DOSE ASSESSMENT METHOD

2.1 Exposure Calculation Methodology

2.1.1 Exposure Calculation at the Mine

The main exposure pathways for Mine workers are inhalation of Radon Decay Products (RDP), irradiation by gamma radiation and inhalation of radioactive dust. Assessment of exposure from dust and RDP are based on employee time sheet/card information and measurements from the approved monitoring program.

Employee and contractor time card information is entered into one of the three time tracking databases [IRIS, SAP, Production Tracking Normal Time (Prodtrak_Normtime)] for either daily or monthly work periods. The site security database (CARDAX) is also used to determine the monthly average hours for individuals whose timesheets have not been logged into any of the other databases mentioned above. The information from CARDAX is converted into tables that can be easily imported into the IRIS database for dose calculation. Each database records employee name, employee number, occupation, date, work location and hours in location information.

Locations within the Mine are grouped into areas of 'like air' known as airways. The Senior Ventilation Engineer or their nominee, who is familiar with the underground environment, maintains the locations within the airways. Airways are segregated into weekly periods and new locations are mapped into their relevant airway this results in there being 13 weekly groupings each quarter covering the history of ventilation throughout the Mine.

The RDP concentration is then determined for each airway for each week using measurements from the approved monitoring program, which covers monitoring of most active work areas. For work airways not sampled in that week, an average is calculated. This average is calculated from all readings for that particular airway over the quarter.

Employee exposure to radioactive dust is calculated using quarterly occupation-based averages. The averages are obtained from monitoring performed under the approved monitoring program. An occupation-based dust concentration level is then allocated to each occupation.

The occupation-based dust concentration information and location-based RDP concentration information is then combined with the employee time card information to derive individual exposure data. Dust exposure is measured in units of Becquerel-hours per cubic metre ($Bq.hr/m^3$) and RDP concentration is measured in units of micro Joule-hours per cubic metre ($\mu J.hr/m^3$). Exposure details are combined to give quarterly personal exposures.

The entire procedure is processed using a software program known as the Integrated Radiation Information System (IRIS). The system is designed such that the Radiation Safety Officer is required to perform checks in each step of the process. This is in addition to a built-in auditing system within the program.

Respiratory protection in the form of airstream helmets are available for all employees and are worn when tasks are identified as requiring them. They are typically worn by some workgroups such as Ore Handling Beltrunners and Services Ventilation Crew. Airstream helmets are also mandatory for identified specific tasks or in certain conditions. Routine and non-routine use of airstream helmets is monitored and logged.

No respiratory protection factors are used in these exposure calculations, and therefore actual individual exposures will be lower than reported.

Exposure to gamma radiation is assessed using Thermo Luminescent Dosimeters (TLD's) badges from the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Personal Monitoring Service. TLD badges are worn for a period of three months; non-badge wearers are allocated an occupation-based average exposure.

2.1.2 Exposure calculation in the Metallurgical Plant

The main exposure pathways for Metallurgical Plant workers are inhalation of radioactive dust and fumes, and irradiation by gamma radiation. Assessment of exposure from dust and fumes is based on employee time sheet/card information and measurements from the approved monitoring program. Dust exposure in the Metallurgical Plant may involve exposure to different types of dust. These dusts will differ in particle size and radionuclide composition, which will produce different dust Dose Conversion Factors (DCF's). The table of DCF's is given in Appendix A.

Information from employee and contractor time cards or employee activity sheets is entered into IRIS via one of the three databases [IRIS (Manual), SAP, Prodtrak] containing daily or monthly information, depending on work area and occupation. From these databases a file of unique locations/occupations is obtained. Locations of the same section or similar exposure are grouped into exposure groups. A quarterly mean of dust activity is determined for each of the exposure groups based on the results of the monitoring program.

CARDAX is used to extract time sheet information for all personnel where it is not possible to get this information from the three main databases commonly used at Olympic Dam for timesheet logging (IRIS, Prodtrak and SAP).

Quarterly location/occupation dust averages are combined with time information to produce a dust exposure for each employee and each different dust type.

Exposure to gamma radiation is assessed using TLD badges from the Personal Monitoring Service of ARPANSA. TLD badges are worn for a period of three months. They are issued to all occupation groups with designated employees. The balance of employees receive the average exposure for their occupation group. TLD badges are issued to different employees every monitoring period. Employees from occupation groups which are likely to receive elevated gamma dose are issued a TLD badge each monitoring period (eg. Slag Crushers, Mill Technician, Product Packer, Slag Handling Technician, TRS Technician, Instrumentation Technician working with radiation gauges). Spare TLD badges are also kept on hand to be issued to employees upon request.

Although the exposure to RDP within the Metallurgical Plant is much less than other pathways, it is assessed in the same way as for Mine employees. The same time information used for calculation of dust exposure is used for calculating RDP exposure. All surface locations/occupations are grouped into one surface airway. A weekly average is calculated from all surface RDP measurements and is assigned to this airway. Location-based RDP concentration information is then combined with the employee time card information to derive individual weekly exposure data ($\mu J.hr/m^3$).

2.2 Exposure to Dose Calculations

Conversion of dust exposure to committed effective dose is achieved by the use of dose conversion factors, which are derived using the methodologies in International Commission on Radiological Protection (ICRP) 68/72. The parameters physically measured to determine the factors are; particle size and radionuclide content. These measurements are undertaken in a number of areas of the Mine and Metallurgical Plant.

Analysis of the samples used to determine the radionuclide content was carried out by the Olympic Dam Analytical Laboratory. These results were used to determine dose conversion factors, which remain unchanged from last year.

Changes to existing conversion factors will only occur in the event of introduction of new processing techniques, major changes to plant or ore type or new recommendations published by the ICRP. A summary of the dose conversion factors used for 2010/2011 is given in Appendix A. Dose conversion factors have been carried over from the previous reporting year.

To calculate committed dose for airborne dust exposure, the airborne dust exposure is multiplied by the appropriate dose conversion factor. The committed doses for the different dusts are then added to give a total airborne dust dose.

Dose equivalent from RDP are calculated by multiplying the RDP exposure by the default dose conversion factor recommended by ICRP65 of 1.41 $mSv.m^3/mJ.hr$ (5 mSv/WLM).

3 Employee Doses

3.1 Doses to Mine Employees

3.1.1 Descriptive Statistics

A total of 808 full-time designated Mine worker's doses were calculated for the period 1st July 2010 to 30th June 2011. This included all BHP Billiton Olympic Dam Mine employees and associated contractors. The distribution of doses for these work classifications is given in Figure 1.

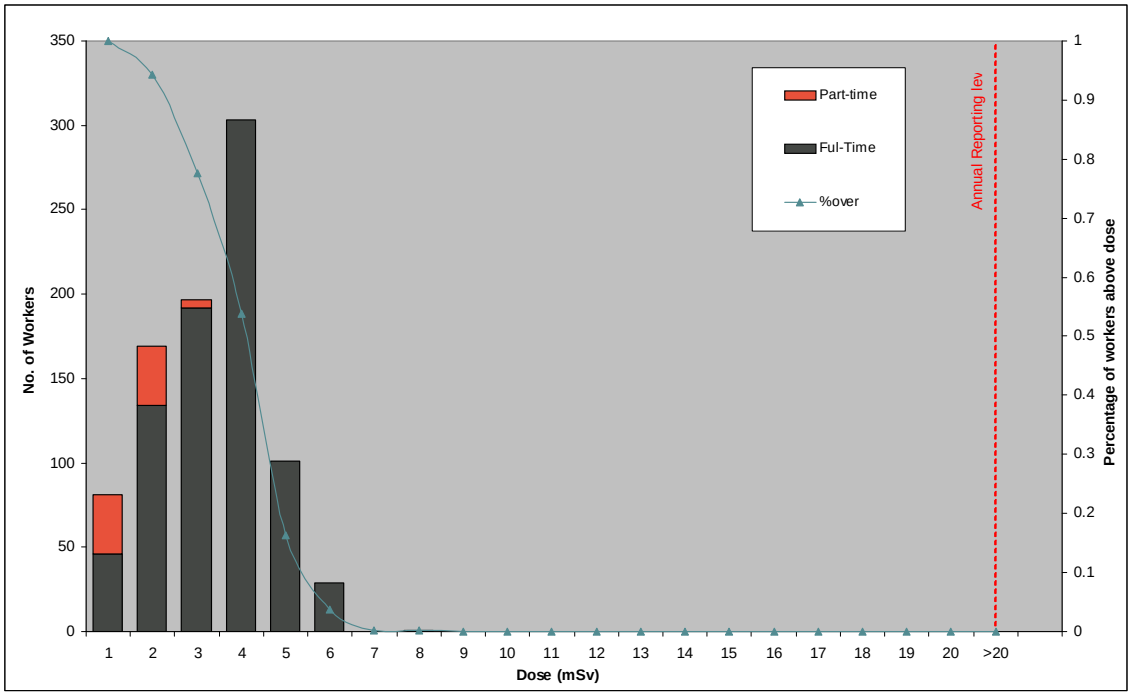


Figure 1 – Annual Dose Distribution 2010/2011 for All Designated Employees - Mine

The selection criteria for determining whether employees are categorised as 'full- time' or 'part-time' is as follows:

A 'full-time' Mine employee is an employee whose dose has been assessed for a total of three or more quarters in the Mine. A 'part-time' employee therefore has dose assessment for less than three quarters. This eliminates any unintentional biasing of the analysis of data due to short exposure periods.

The mean dose to all designated mine employees was 2.9 mSv in 2010/2011, an increase from the 2009/2010 value of 2.8 mSv.

The mean dose for full-time designated mine workers was 3.0 mSv in 2010/2011, an increase from the 2009/2010 value of 2.9 mSv.

The mean dose for part-time designated mine workers was 2.1 mSv in 2010/2011, an increase from the 2009/2010 value of 1.5 mSv.

The average exposure to radon decay products (RDP) in the underground mine for 2010/2011 was 59% just greater the 2009/2010 value of 58%.

Table A consolidates the results for the exposures at the mine.

Table A – Statistics for designated employees, mine

Statistics	Full-Time Designated Employees	Part-Time Designated Employees	All Designated Employees
Count	808	75	883
Arithmetic Mean (mSv)	3.0	2.1	2.9
90th Percentile (mSv)	4.3	1.9	4.1
Min (mSv	0.4	0.1	0.1
Max (mSv)	7.1	2.3	7.1
Mean % Dose from RDP	59%	54%	59%
Mean % Dose from Dust	4%	3%	4%
Mean % Dose from Gamma	37%	43%	37%

No Mine worker received an annual dose greater than 10 mSv. The highest dose was 7.1 mSv, compared to a maximum value in 2009/2010 of 7.3 mSv.

3.1.2 Review of doses by work category

Table B shows the breakdown of doses by work category for full-time designated employees.

The total number of all designated employees has increased to 883 in the 2010/2011 year from 739 in 2009/2010. The primary focus of our monitoring programs has remained on the critical workgroups that are currently working in the underground mine.

Of the three major exposure pathways (gamma irradiation, inhalation of radioactive dust and inhalation of RDP), the gamma irradiation exposure levels for full-time designated workers has remained the same at 37%. While RDP has increased marginally from 58% in 2009/2010 to 59% of the total dose in 2010/2011. The dust component remains low at 4% of the total dose.

Average annual doses for all mine work groups have varied and are well within historical variations. Some workgroups have seen slight increases from 2009/2010 due to the return to full production in the 2010/2011 year. The Raise Driller work group received the highest average dose of 4.7 mSv the same as 2009/2010. The highest individual annual dose of 7.1 mSv was also received by a Raise Driller.

The dose components for all work categories are shown graphically in Figure 2.

Table B – Statistics for Full Time Designated Mine Employees

WORK CATEGORY	No. of Emp.	Mean (mSv)	Minimum (mSv)	Maximum (mSv)	90th Percentile (mSv)
Backfill	2	0.7	0.4	1.0	0.9
Core Processing	3	0.7	0.6	0.8	0.8
Development	165	3.5	0.8	5.7	4.4
Diamond Drilling	25	2.4	0.5	3.8	3.4
Electrician	24	2.4	0.9	4.0	3.9
Fitter	50	1.6	0.7	2.7	2.2
Mine Surface	156	1.8	0.5	4.4	2.8
Ore Handling	152	3.3	1.5	4.9	4.2
Production Charging	20	4.7	2.7	5.9	5.7
Production Drilling	47	3.8	2.5	5.8	4.6
Raise Drilling	13	4.7	2.6	7.1	5.9
Underground Services	149	3.2	0.8	5.6	4.6

WORK CATEGORY	RDP. Average (mSv)	RDP. % of Total Dose	Gamma Average (mSv)	Gamma % of total Dose	Dust Average (mSv)	Dust % of Total Dose
Backfill	0.1	12%	0.6	80%	0.1	8%
Core Processing	0.1	13%	0.3	38%	0.3	49%
Development	2.2	62%	1.3	36%	0.1	2%
Diamond Drilling	1.5	62%	0.9	36%	0.0	2%
Electrician	1.1	46%	1.1	47%	0.2	7%
Fitter	0.8	50%	0.7	44%	0.1	6%
Mine Surface	1.0	51%	0.7	39%	0.2	10%
Ore Handling	2.2	65%	1.1	33%	0.1	2%
Production Charging	2.4	51%	2.1	44%	0.2	5%
Production Drilling	2.1	56%	1.5	40%	0.1	3%
Raise Drilling	2.8	60%	1.7	35%	0.2	5%
Underground Services	1.9	60%	1.2	36%	0.1	4%

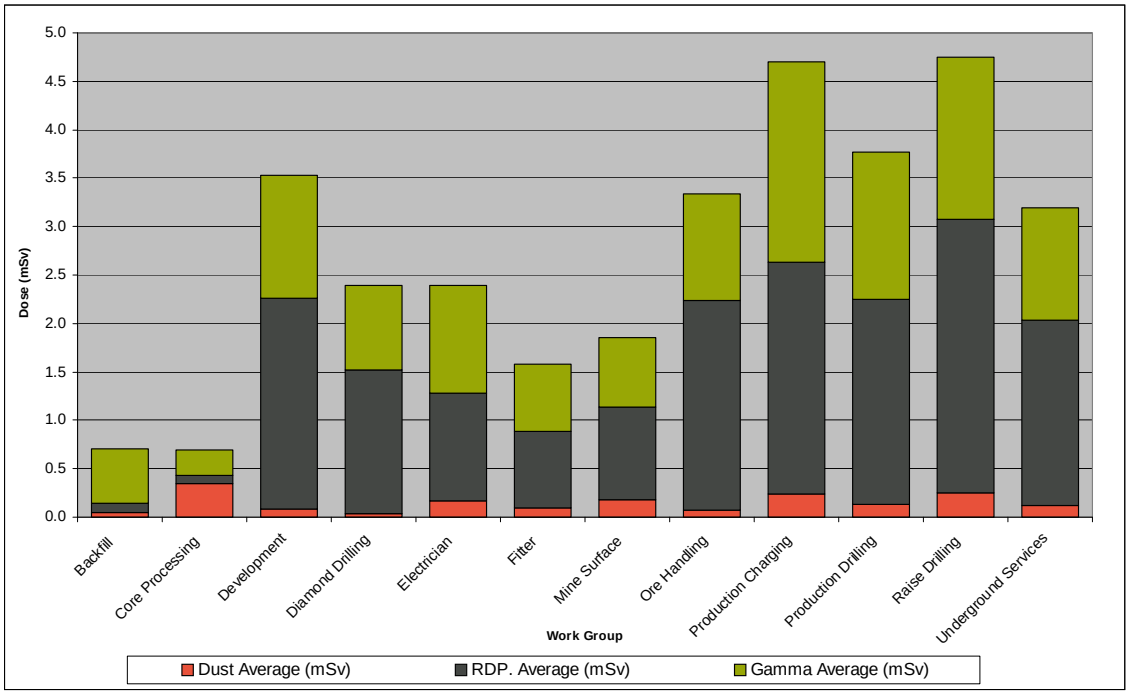


Figure 2 – Doses, showing components, for Full Time Designated Mine Employees

The average and maximum effective dose for the critical Mine underground workgroups and dose component trends for selected workgroups are given from Figure 3 - Figure 26.

Backfill

The average dose to the Backfill workgroup has decreased from 1.5 mSv to 0.7 mSv whilst the maximum dose to this workgroup has decreased from 2.1 mSv to 1.0 mSv. This reflects the nature of Backfill employee's surface work that spend minimal time underground while in the 2009/2010 year some employees had transferred from underground roles to surface roles in Backfill.

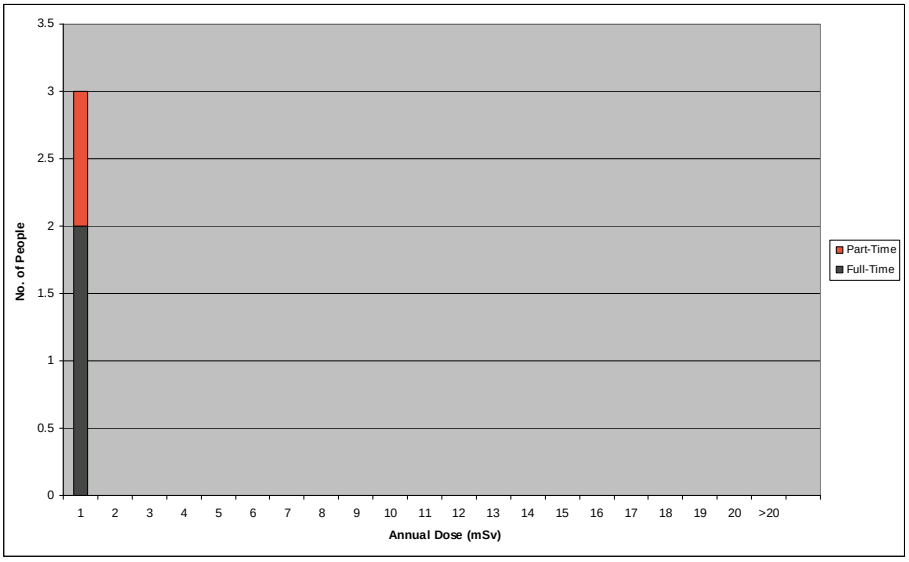


Figure 3 – Annual Dose Distribution for the Backfill Workgroup

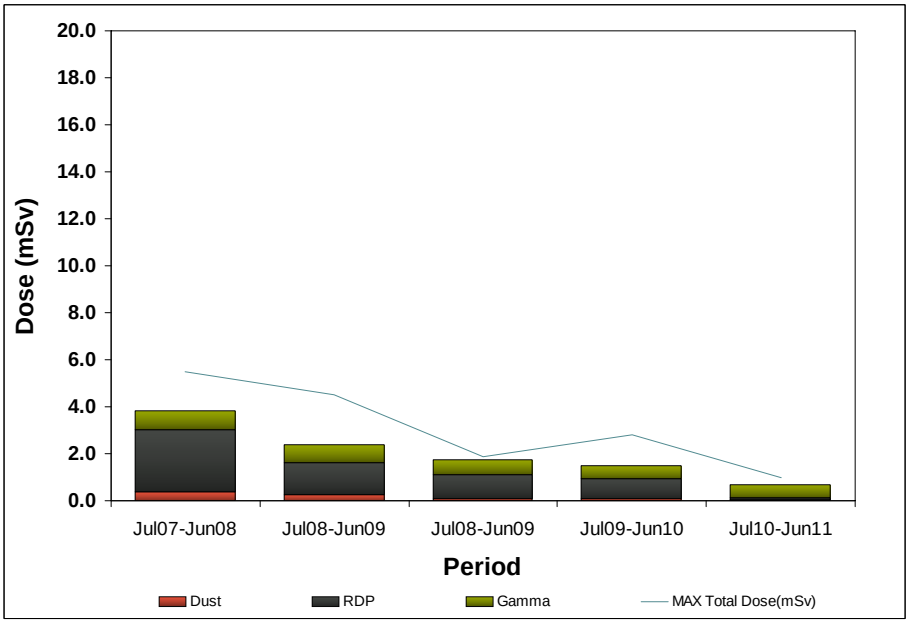


Figure 4 – Annual Dose Trends for the Backfill Workgroup

Core Processing

The average and maximum doses to Core Processing employees have remained at low levels under 1mSv per year. The average dose for 2010/2011 was 0.7 mSv and the maximum dose was 0.8 mSv. Dust exposure to this workgroup has been assessed for occupational hygiene purposes and the installation of a new local exhaust ventilation system is scheduled by the end of June 2012. This will further reduce radiation exposures to this workgroup.

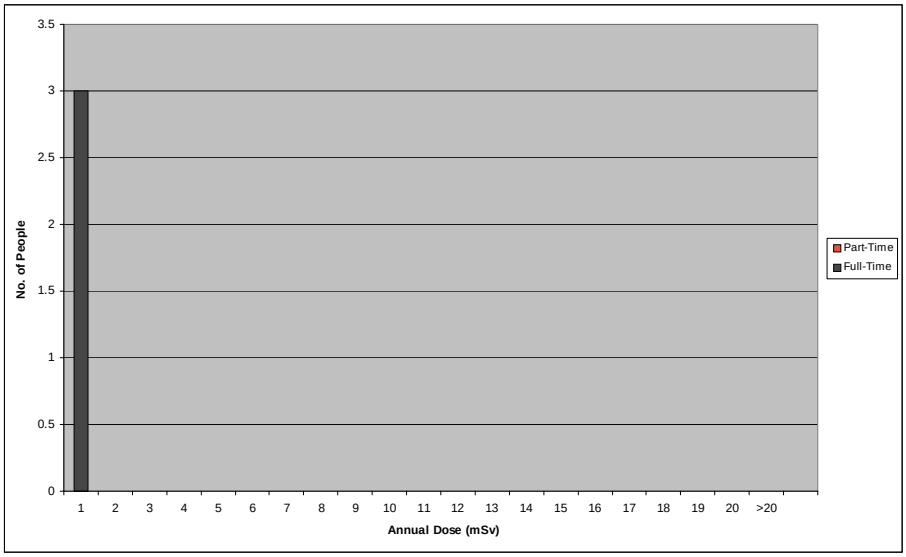


Figure 5 – Annual Dose Distribution for the Core Processing Workgroup

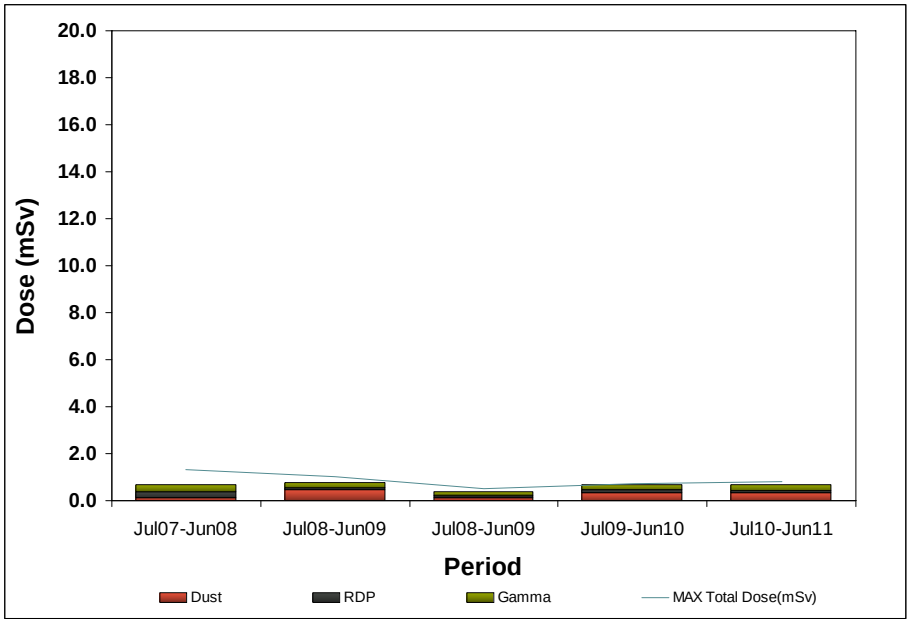


Figure 6 – Annual Dose Trends for the Core Farm Workgroup

Development

The average and maximum dose to the Development workgroup has increased from 3.4 mSv and 5.3 mSv to 3.5 mSv and 5.7 mSv respectively. This is a result of increased development activities due to the return to full production in 2010/2011. Exposures are still below levels seen in previous full production years.

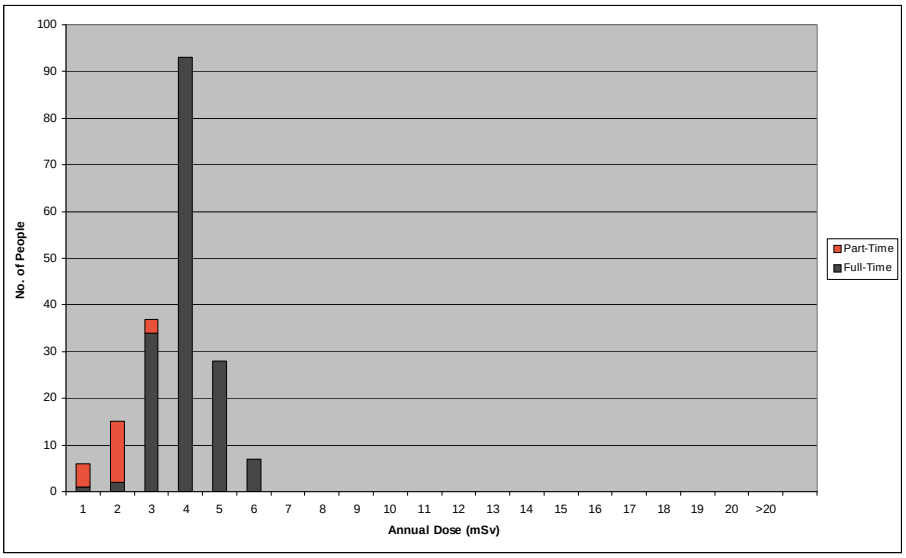


Figure 7 – Annual Dose Distribution for the Development Workgroup

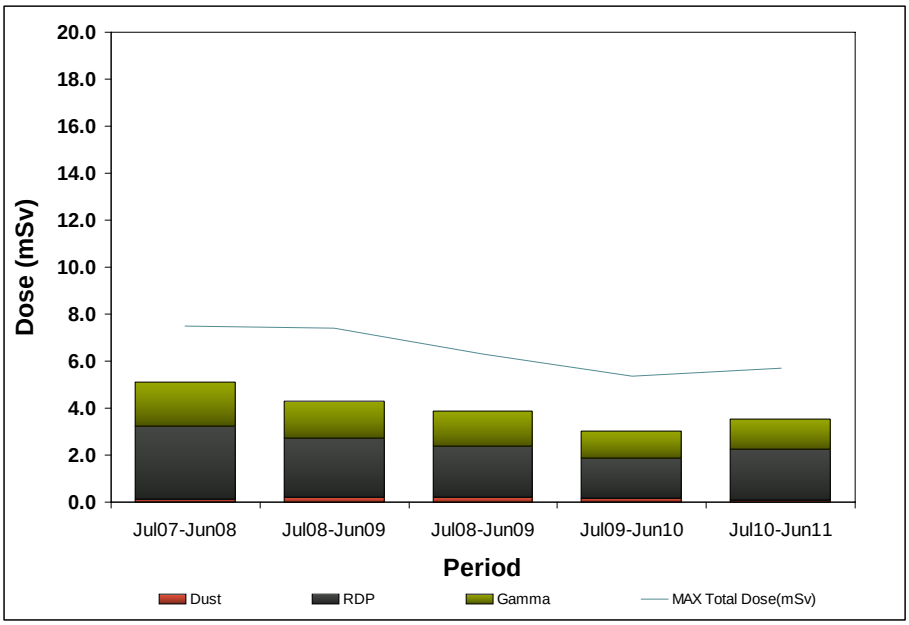


Figure 8 – Annual Dose Trends for the Development Workgroup

Diamond Drilling

The average and maximum dose to the Diamond Drilling workgroup has decreased from 3.0 mSv and 4.3 mSv to 2.4 mSv and 3.8 mSv respectively. The significant reduction in dose for this workgroup over the last few years is primarily a result of decreased gamma and radon decay product exposures with improved site set up.

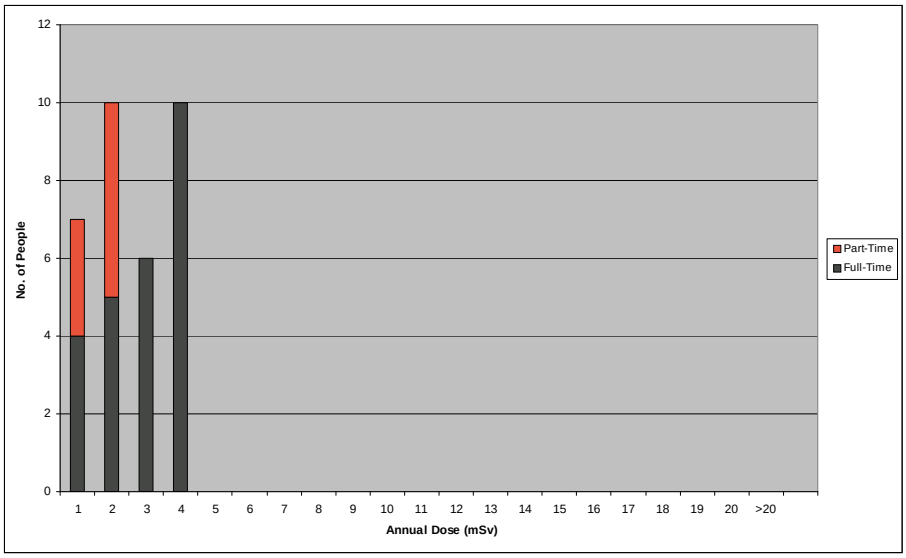


Figure 9 – Annual Dose Distribution for the Diamond Drilling Workgroup

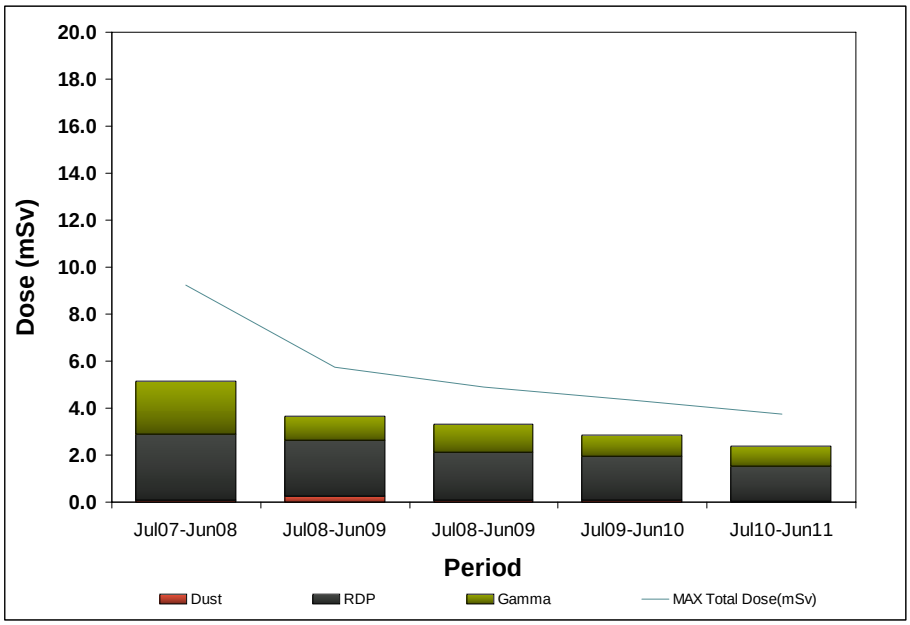


Figure 10 – Annual Dose Trends for the Diamond Drilling Workgroup

Electrician

The average dose to electricians has decreased slightly to 2.4 mSv from 2.5 mSv in 2009/2010 while the maximum dose to this workgroup has decreased from 5.6 mSv in 2009/2010 to 4.0 mSv. This decrease for exposures reflects the reduced number of electrician contractors spending time underground after major contractor work was performed in 2009/2010.

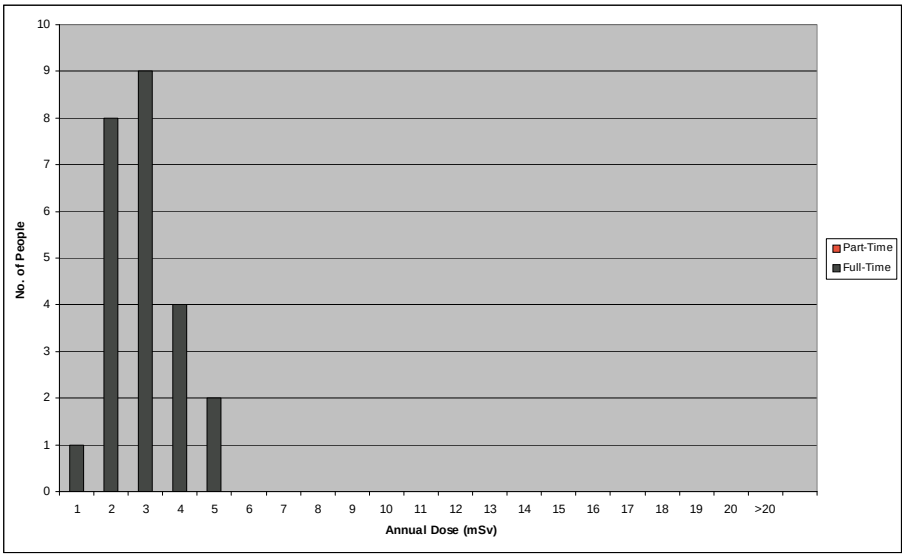


Figure 11 – Annual Dose Distribution for the Electrician Workgroup

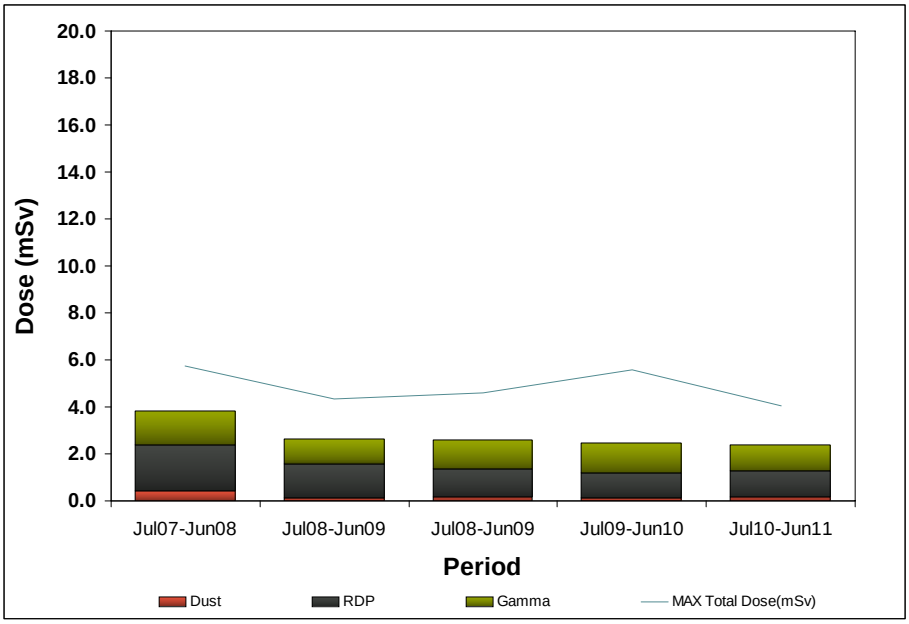


Figure 12 – Annual Dose Trends for the Electrician Workgroup

Fitter

The average dose to the Fitter workgroup has decreased from 1.8 mSv to 1.6 mSv whilst the maximum dose for Fitters has decreased from 4.1 mSv to 2.7 mSv. These doses are in line with normal variations and do not reflect any significant changes in work practices for this workgroup.

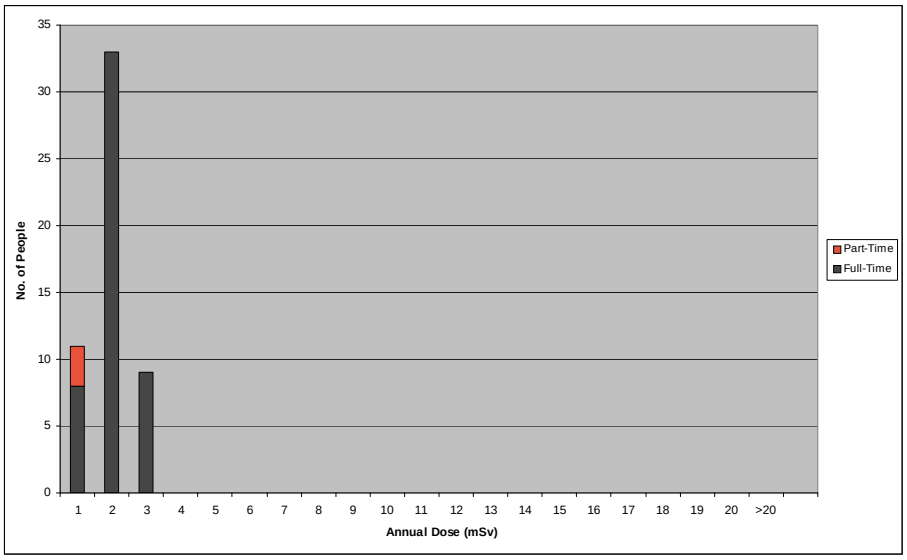


Figure 13 – Annual Dose Distribution for the Fitter Workgroup

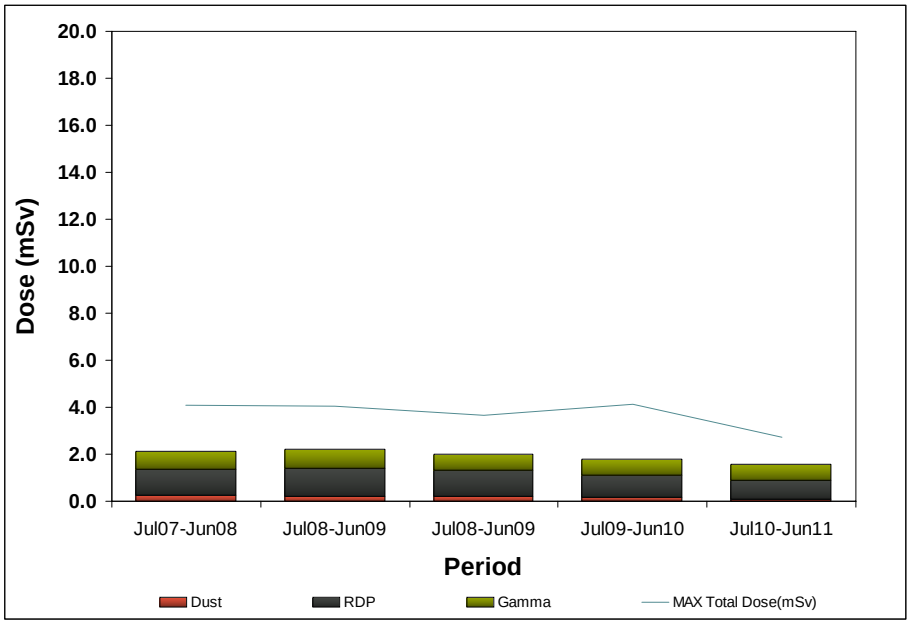


Figure 14 – Annual Dose Trends for the Fitter Workgroup

Mine Surface

The average dose has remained the same at 1.8 mSv and the maximum dose has increased from 3.6 mSv to 4.4 mSv. These doses are in line with normal variations and do not reflect any significant changes in work practices for this workgroup.

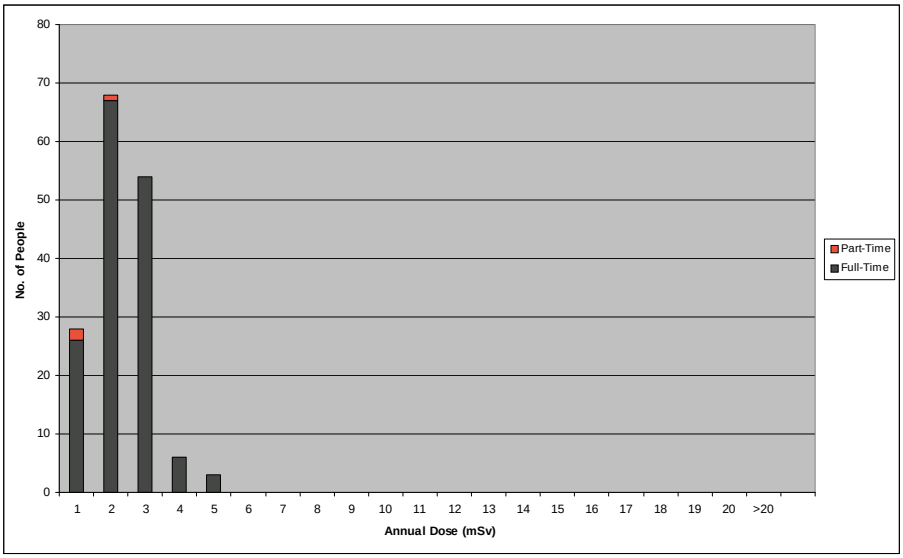


Figure 15 – Annual Dose Distribution for the Surface Workers Workgroup

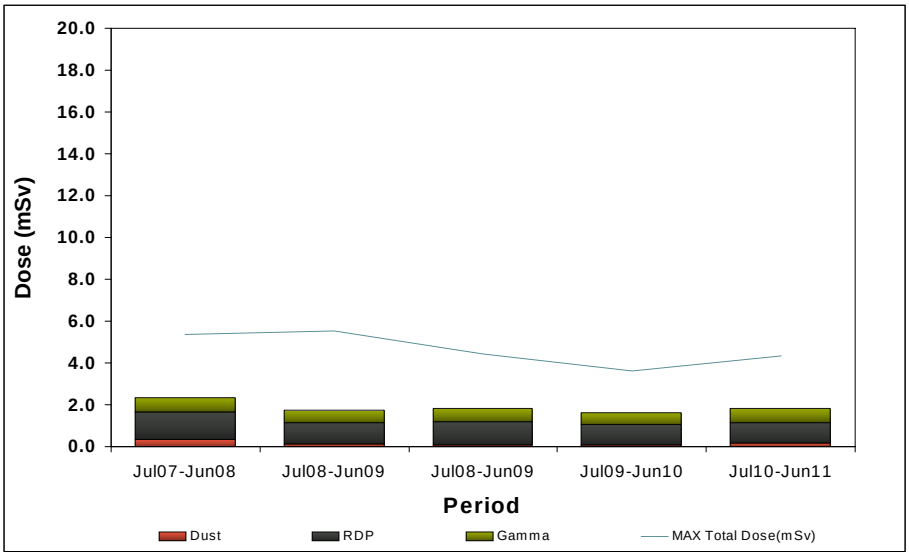


Figure 16 – Annual Dose Trends for the Surface Workers Workgroup

Ore Handling

The average dose has remained steady at 3.3 mSv while the maximum dose has decreased slightly from 5.0 mSv to 4.9 mSv. These doses are in line with normal variations and do not reflect any significant changes in work practices for this workgroup.

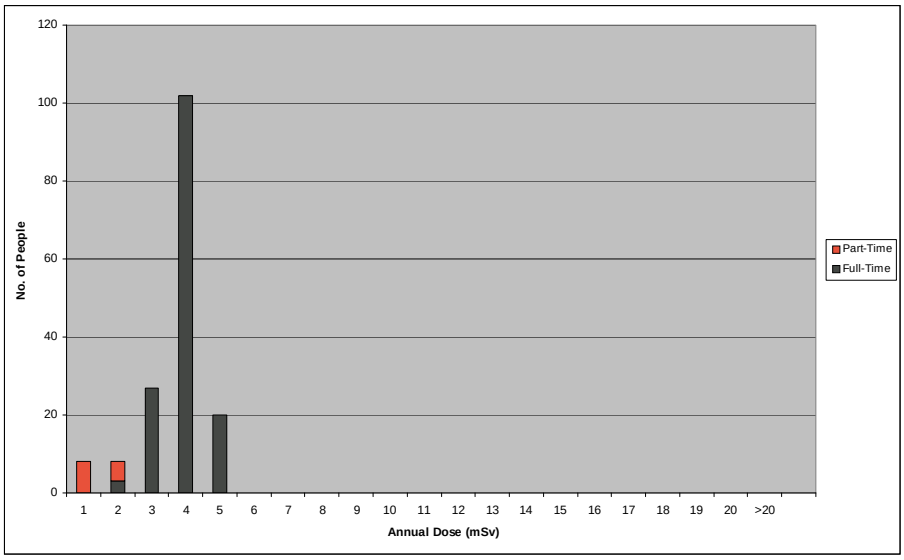


Figure 17 – Annual Dose Distribution for the Ore Handling Workgroup

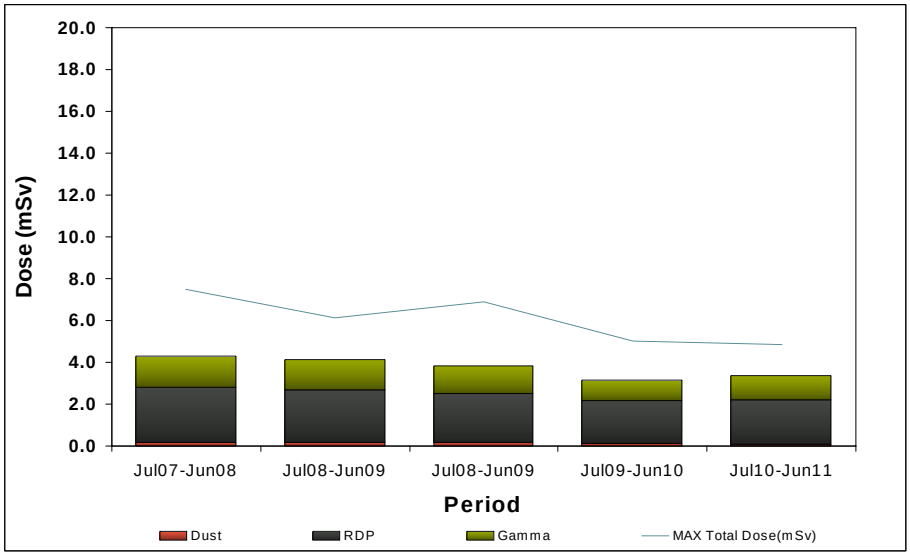


Figure 18 – Annual Dose Trends for the Ore Handling Workgroup

Production Charging

The average dose for Production Chargers has increased from 4.1 mSv to 4.7 mSv while the maximum dose also increased from and 5.2 mSv to 5.9 mSv. The increase in exposures is a result of the return to full production activities in the 2010/2011 year and is in line with historical exposures recorded for the workgroup.

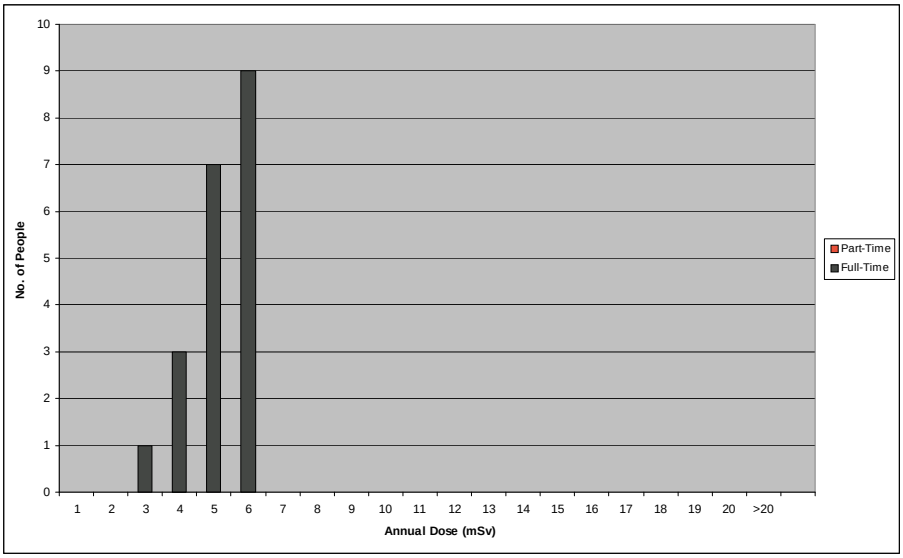


Figure 19 – Annual Dose Distribution for the Production Charger Workgroup

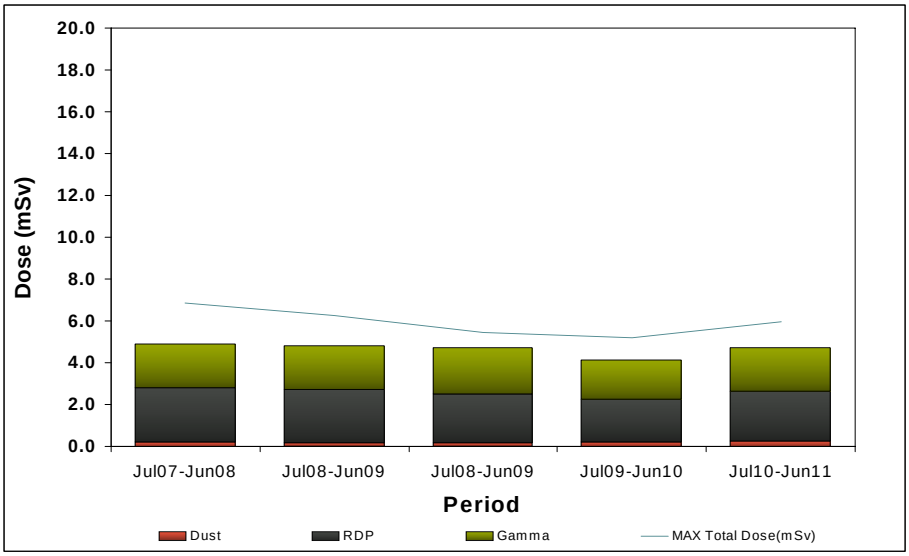


Figure 20 – Annual Dose Trends for the Production Charger Workgroup

Production Drilling

The average dose for the production drillers has increased from 3.5 mSv to 3.8 mSv and the maximum dose has also increased from 5.3 mSv to 5.8 mSv. The increase in exposures is a result of the return to full production activities in the 2010/2011 year and is in line with historical exposures recorded for the workgroup.

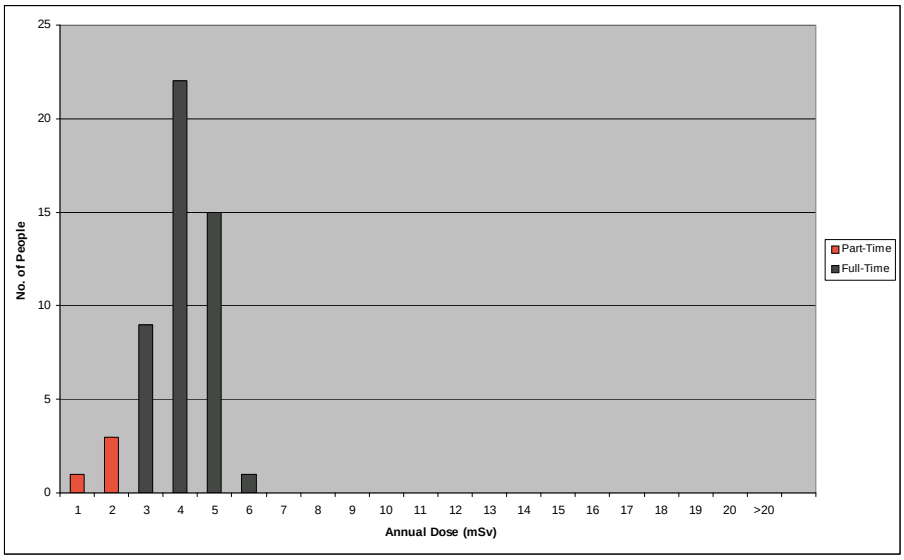


Figure 21 – Annual Dose Distribution for the Production Driller Workgroup

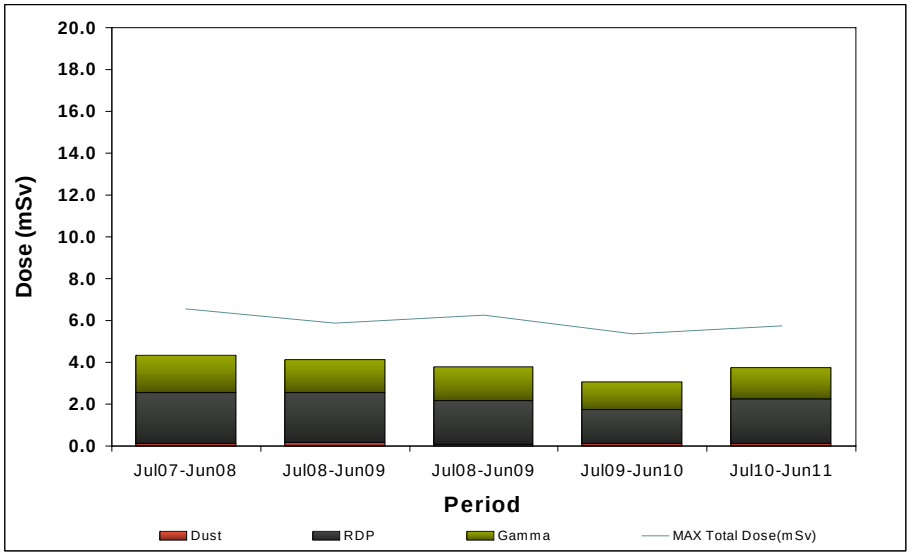


Figure 22 – Annual Dose Trends for the Production Driller Workgroup

Raise Drilling

The average dose has remained at 4.7 mSv and the maximum dose has decreased from 7.3 mSv to 7.1 mSv. Focus on radon decay product exposure continues to be the main priority for radiation exposure to this workgroup. The radon project has already begun to investigate enclosed operator consoles and air filtration systems for this workgroup. Implementation of an engineering control to reduce their exposures is expected to occur by the end of 2012.

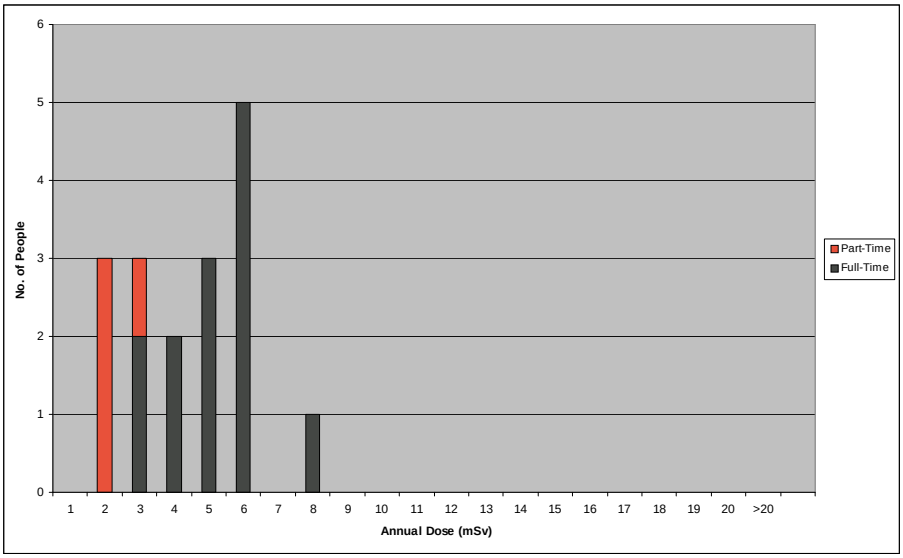


Figure 23 – Annual Dose Distribution for the Raise Driller Workgroup

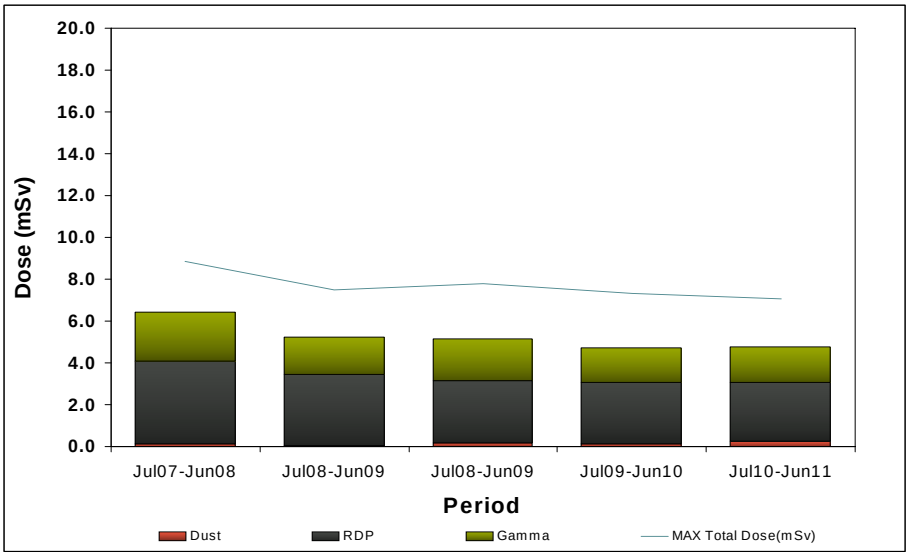


Figure 24 – Annual Dose Trends for the Raise Driller Workgroup

Underground services

The average dose has increased from 2.7 mSv to 3.2 mSv and the maximum dose has increased from 5.4 mSv to 5.6 mSv. The increases are a result of the return to full production in 2010/2011 and in line with historic exposures.

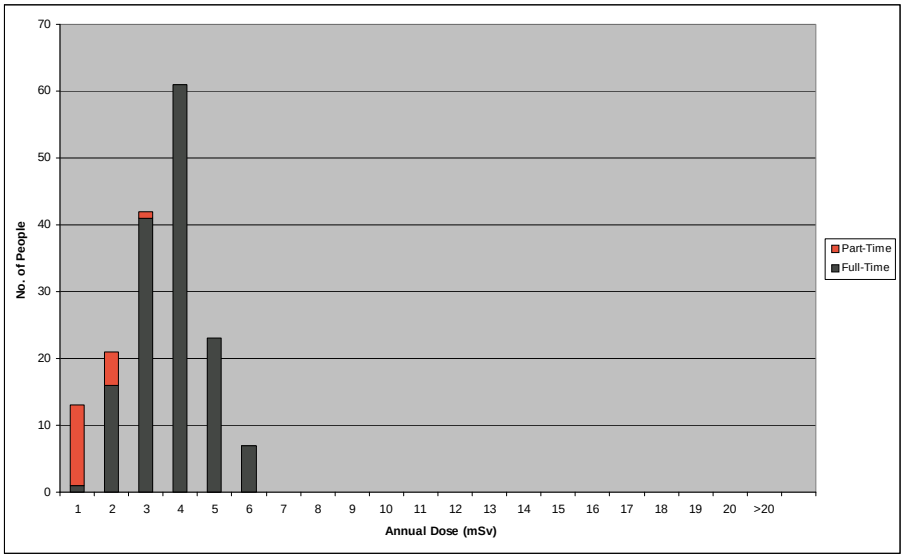


Figure 25 – Annual Dose Distribution for the Underground Services Workgroup

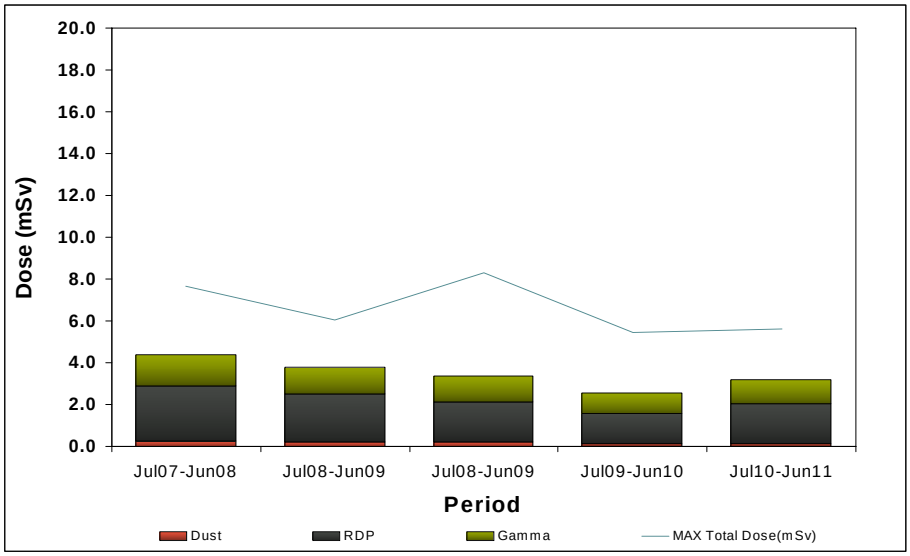


Figure 26 – Annual Dose Trends for the Underground Services Workgroup

3.1.3 Strategies for Dose Reduction

There is a continuous focus on reducing dose to employees at the mine and some of these measures include;

- Finalising approval of the new Radiation Management Plan
- The use of the electronic tag board system to capture employee time spent underground
- Use of a continuous radon decay product monitor at the 420 platform to determine exposures when employees spend time at that location
- Continuing use of electronic gamma dosimeter monitoring programs
- Extensions to the existing ventilation system
- Investigation for monitoring of exposure to employees who work in air-conditioned filtered mining equipment
- Trial of personal radon decay product monitors
- Proposed trial of secondary fan filtration units
- Focused radiation monitoring for the higher exposed work groups

In early FY11 a radon steering committee was established to determine and implement controls for the reduction of exposure to radon decay products underground. A number of the dose reduction strategies are a result of actions from the steering committee.

The mine ventilation department have continued to focus on ensuring that exposure to radon decay products are minimised through continued extensions of the Mine ventilation systems when required.

In March 2011 the Radiation & Occupational Hygiene Technicians were placed on a 4/5 day shift roster. This has provided better underground coverage from the department and an increase in the measurements performed in excess of the required monitoring program.

3.1.4 Doses to Non-Designated Mine Employees

A dose distribution for non-designated employees and contractors at the Mine is listed in Figure 27. Non-designated employees are tracked individually on the same dose calculation system as the designated employees. A summary of all non-designated employee doses is given in Table C

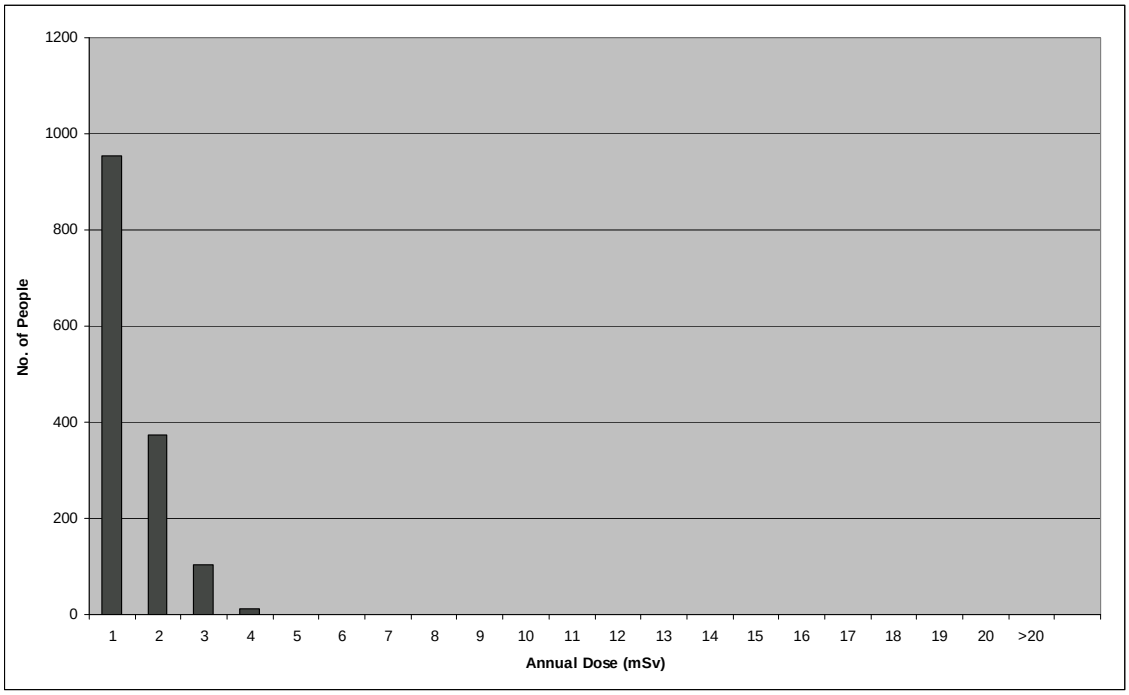


Figure 27 – Annual Dose Distribution for Non-Designated mine end employees

Table C – Non Designated Mine Employee Statistics

Statistics	Non Designated Employees
Count	1441
Arithmetic Mean (mSv)	1.0
90th Percentile (mSv)	1.8
Min (mSv	0.2
Max (mSv)	3.5
Mean % Dose from RDP	33%
Mean % Dose from Dust	15%
Mean % Dose from Gamma	52%

Maximum and average dose trends for all non-designated mine workers are presented in Figure 28.

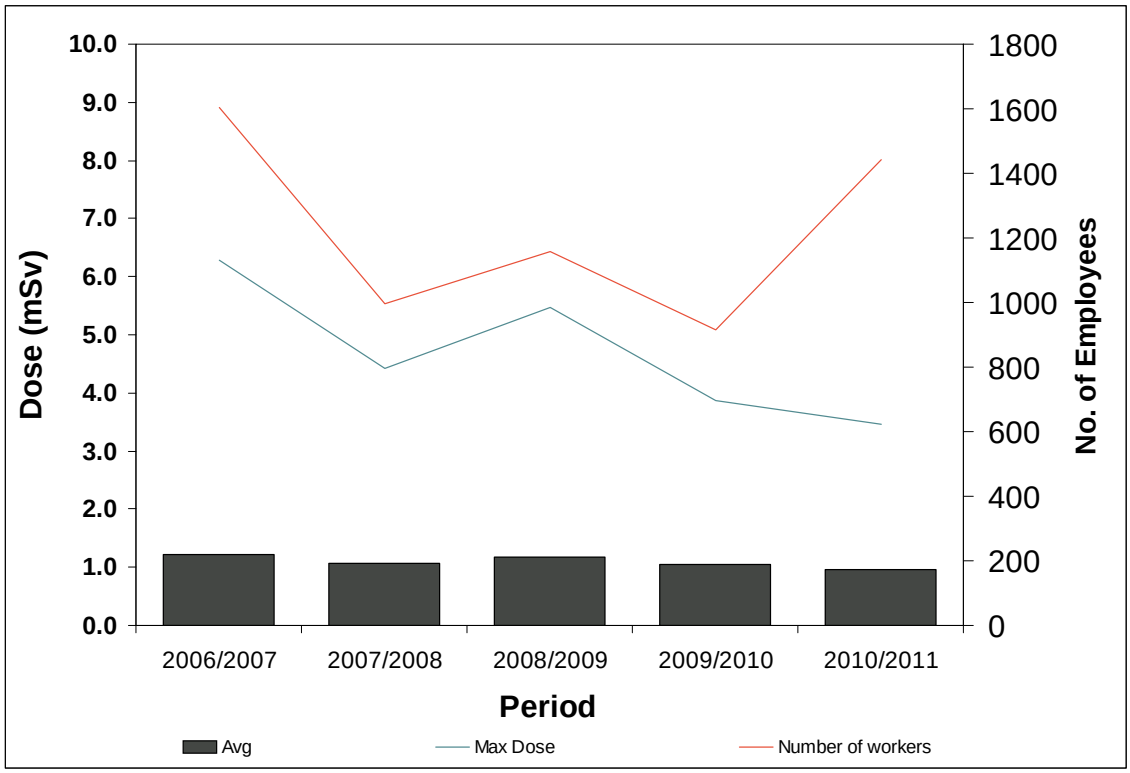


Figure 28 – Average Dose Trends for Non-Designated Employees

Airborne dust doses and radon decay product doses have been calculated using average airborne dust measurements, average radon decay product measurements, dose conversion factors and either an estimation of the hours worked based on a typical working roster, or actual hours. Gamma doses have been estimated based on direct personal monitoring and averages resulting from this monitoring.

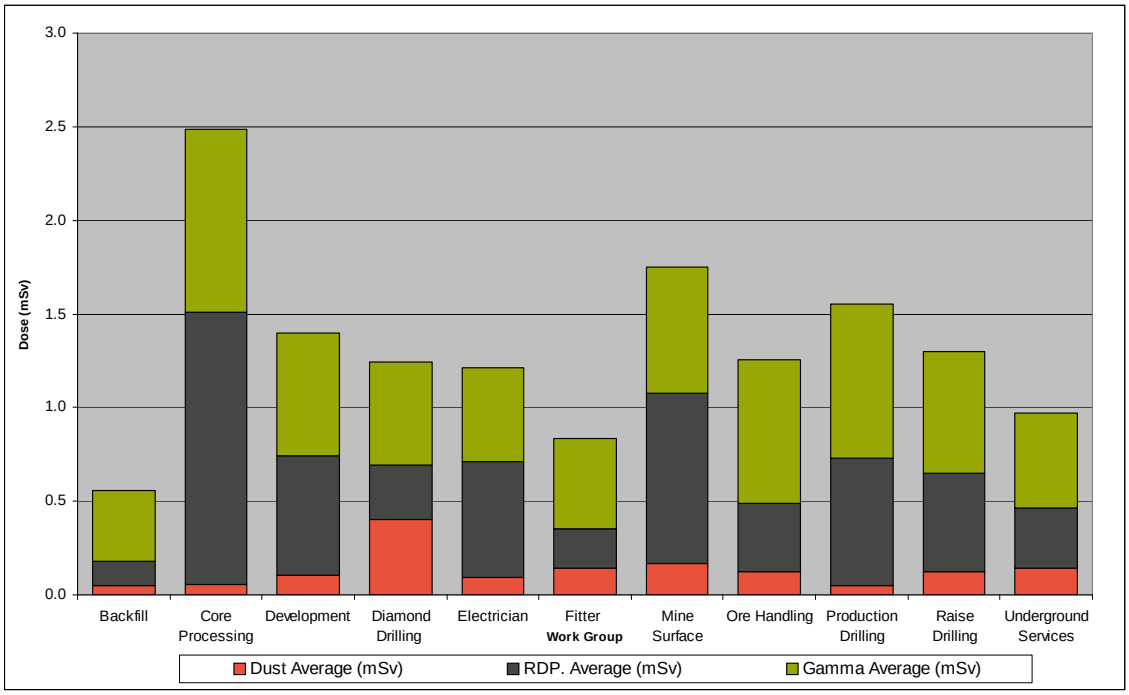


Figure 29 – Annual Doses for Non-Designated employees, by source and by Occupation

Figure 29 shows maximum and average dose trends for all non-designated Mine workers from 1 July 2006 to 30 June 2011.

The total number of non-designated employees has increased from 917 in 2009/2010 to 1441 in 2010/2011. The average dose has remained the same at 1.0 mSv. Eleven mine employees received a dose above 3 mSv, with the highest being 3.5 mSv. These employees have not been designated because they were recently engaged workers, have recently changed jobs or previously assessed as not needing to be designated.

3.1.5 Cumulative Five Year Dose

As outlined in ICRP 103, the total dose of any individual radiation worker should not exceed 100 mSv in any five year period. To this end, a five year total dose has been determined for all full-time currently designated Mine workers who were employed at Olympic Dam for the previous five years. The calculation of cumulative five year effective dose includes employees who have worked for more than 18 quarters.

There were a total of 639 designated Mine workers who worked continuously at the Mine during the period 1 July 2006 to 30 June 2011. This number has increased from the 471 workers reported for the period 1 July 2005 to 30 June 2010. The maximum dose for a Mine worker is 31.4 mSv for the five year period ending 30 June 2011, as compared with 31.3 mSv for the 2004/2005 to 2009/2010 five year dose period. The arithmetic mean for the group was 13.2 mSv, a decrease from 14.8 mSv for the five year dose period 2004/2005 to 2009/2010.

The number of employees who have continuously worked for five years at the Mine has continued to increase due to an increase in staffing in general over the last few years. The distribution of doses for the cumulative five year dose is shown in Figure 30.

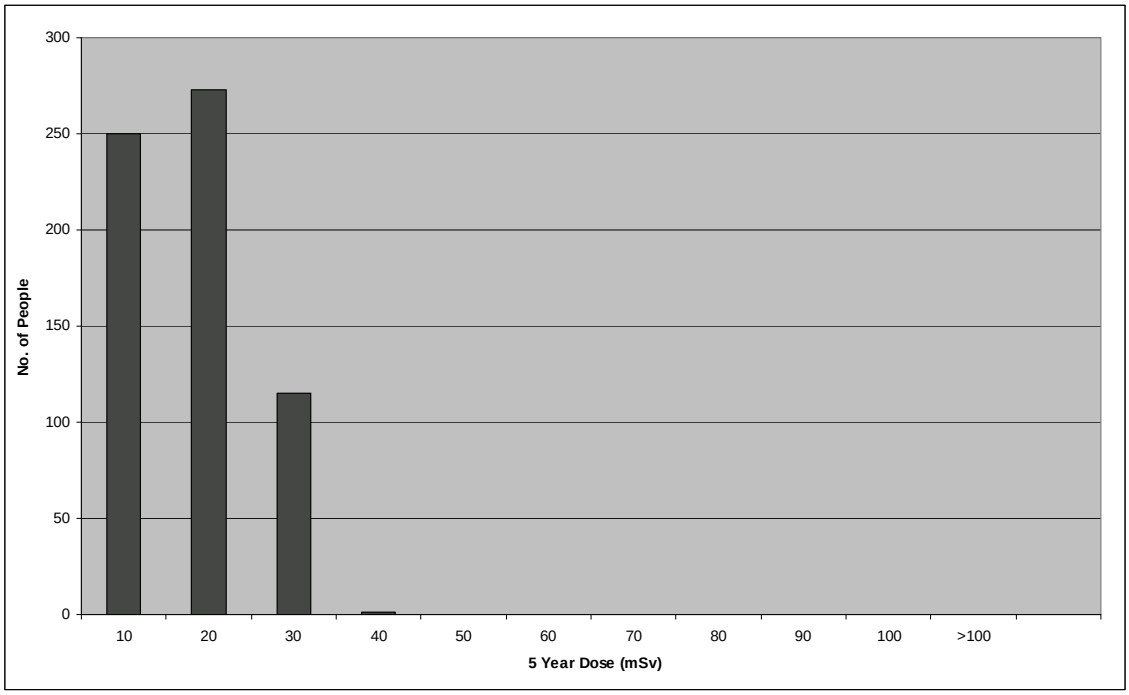


Figure 30 – Five Year Cumulative Dose Distribution Mine

A summary of the cumulative five year dose is given in Table D.

Table D – Five Year Stats

Statistics	Cumulative 5 year Doses	Equivalent Average yearly Dose
	For Continuously Employed Designated Mine Employees	
Count	639	639
Arithmetic Mean (mSv)	13.2	2.6
90th Percentile (mSv)	22.2	4.4
Min (mSv	1.9	0.4
Max (mSv)	31.4	6.3
Mean % Dose from RDP	54%	
Mean % Dose from Dust	16%	
Mean % Dose from Gamma	38%	

3.2 Doses to Metallurgical Plant Employees

3.2.1 Descriptive Statistics

A total of 156 full-time designated Metallurgical Plant worker's doses were calculated for the period 1 July 2010 to 30 June 2011. This included most BHP Billiton Olympic Dam Metallurgical Plant employees and associated contractors who work full time in the plant.

The process plant performed well with no major interruptions. Approximately 10.5 million tonnes of material (ore and slag) was milled producing at total of 194,172

tonnes of copper cathode, 4,045 tonnes uranium oxide concentrate, 111,367 ounces gold bullion and 982,076 ounces silver bullion.

It is important to note that the Clark Shaft incident significantly impacted production in 2009/2010 and as a result doses in that period were lower. With the return to normal production levels in 2010/2011, doses returned to be in line with historical values.

The mean dose to all designated plant employees was 2.0 mSv in 2010/2011, a decrease from the 2009/2010 value of 1.4 mSv.

The mean dose for full-time designated plant workers was 2.1 mSv in 2010/2011, a decrease from the 2009/2010 value of 1.5 mSv.

The mean dose for part-time designated plant workers was 0.4 mSv in 2010/2011, a decrease from the 2009/2010 value of 0.8 mSv.

For this period the distribution of doses is shown in Figure 31, and the statistics are given in Table E.

Table E – Statistics for designated employees, Metallurgical Plant

Statistics	Full-Time Designated Employees	Part-Time Designated Employees	All Designated Employees
Count	156	7	163
Arithmetic Mean (mSv)	2.1	0.4	2.0
90th Percentile (mSv)	5.0	1.0	4.6
Min (mSv	0.3	0.0	0.0
Max (mSv)	6.4	1.1	6.4
Mean % Dose from RDP	6%	13%	7%
Mean % Dose from Dust	80%	56%	78%
Mean % Dose from Gamma	13%	31%	15%

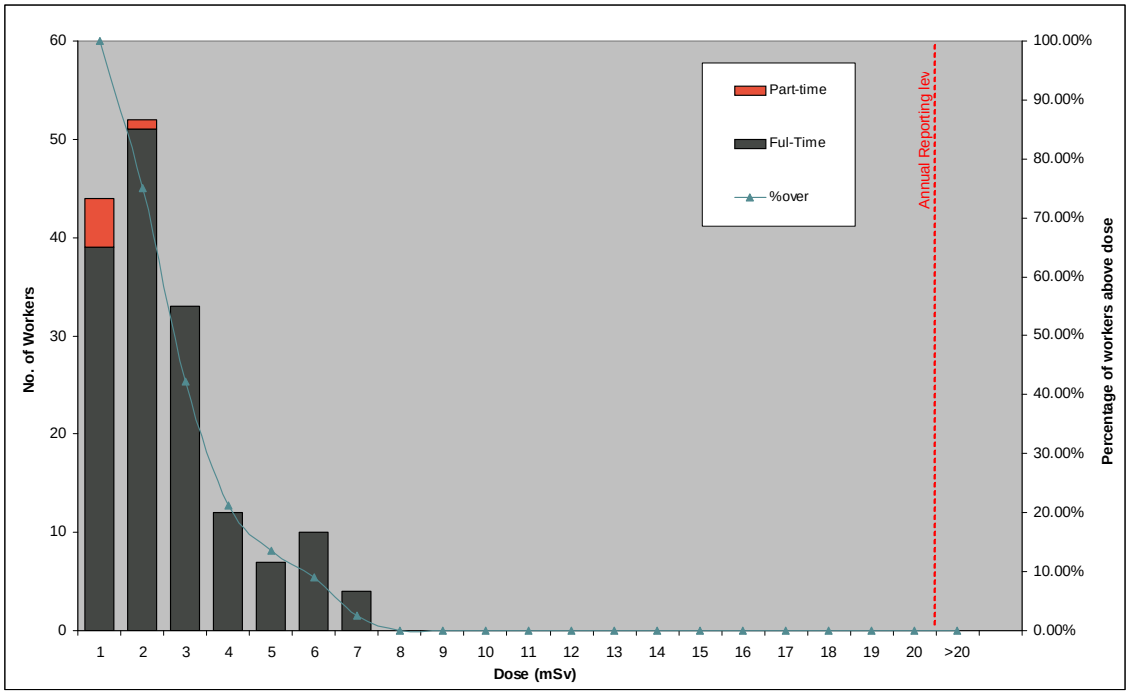


Figure 31 – Annual Dose Distribution for all Metallurgical Plant employees

3.2.2 Review of Doses by Work Areas

The analysis of doses by work area is presented in Table F. The dose statistics for the 2010/2011 year from the Metallurgical Plant areas show an increase in mean dose for all work groups except Hydromet and Services workgroups from the 2009/2010 year. Decreases in the Hydromet and Services workgroups was due to lower dust doses being received.

Individual Work Areas

The highest levels were recorded in the Smelter workgroup. The smelter doses have increased as a result of returning to normal production rates but are lower than the periods before the Clark Shaft incident as polonium 210 is being effectively controlled. The number of full-time designated employees in the Metallurgical Plant has decreased from 193 in 2009/2010 to 156 in 2010/2011.

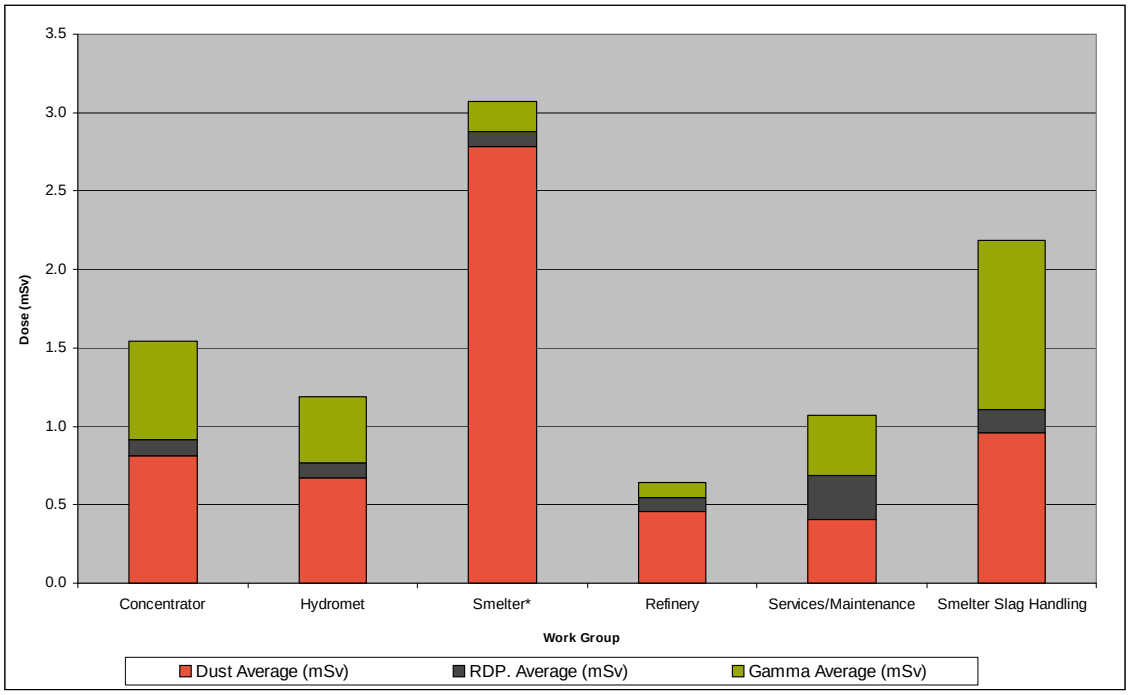
Annual dose components for each work area can be seen in Figure 32.

Table F – Annual Dose Statistics by Work Areas, Full-Time Designated Metallurgical Plant Employees

WORK CATEGORY	No. of Emp.	Mean (mSv)	Minimum (mSv)	Maximum (mSv)	90th Percentile (mSv)
Concentrator	14	1.5	1.0	2.9	2.0
Hydromet	14	1.2	0.9	1.9	1.7
Smelter*	81	3.1	0.8	6.4	5.5
Refinery	14	0.6	0.4	1.1	0.8
Services/Maintenance	33	1.1	0.3	2.3	1.8
Smelter Slag Handling	7	2.1	1.8	2.7	2.7

WORK CATEGORY	RDP. Average (mSv)	RDP. % of Total Dose	Gamma Average (mSv)	Gamma % of total Dose	Dust Average (mSv)	Dust % of Total Dose
Concentrator	0.10	7%	0.63	41%	0.81	52%
Hydromet	0.09	8%	0.42	36%	0.67	57%
Smelter*	0.09	3%	0.19	6%	2.79	91%
Refinery	0.09	14%	0.10	15%	0.46	71%
Services/Maintenance	0.28	26%	0.39	36%	0.41	38%
Smelter Slag Handling	0.15	7%	1.08	51%	0.96	46%

* Smelter work group also includes Slag handling workers



* Smelter work group also includes Slag handling workers

Figure 32 – Annual dose components by workgroup

Annual total dose distributions and dose trends for each work area along with dose component profiles for selected workgroups can be seen in Figure 33 to Figure 42.

Concentrator

Concentrator doses increased slightly due to the return to normal milling rates. The maximum increased was linked to welding fume exposure received by boilermakers in that workgroup. An exposure control plan has been put in place to reduce the welding fume exposure with the key control being the purchase of a new extraction system.

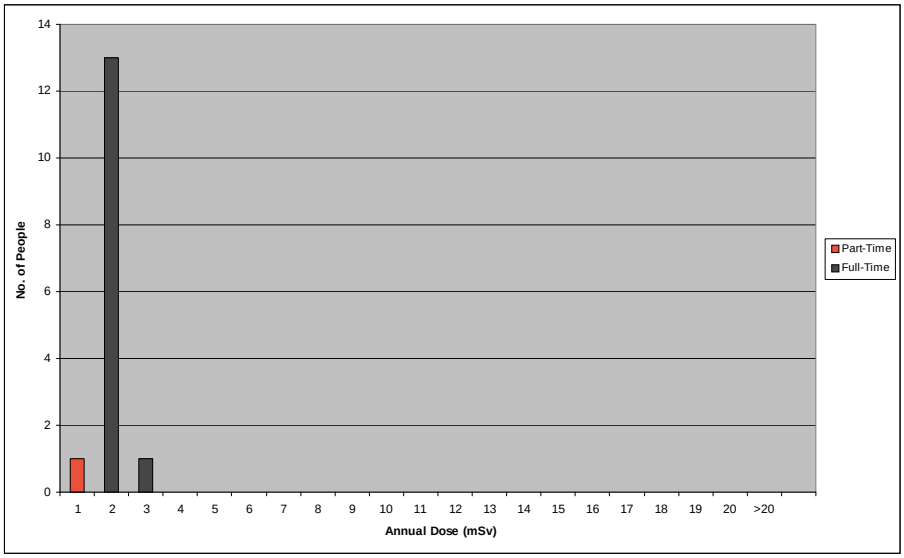


Figure 33 – Annual Dose Distribution for the Concentrator Workgroup

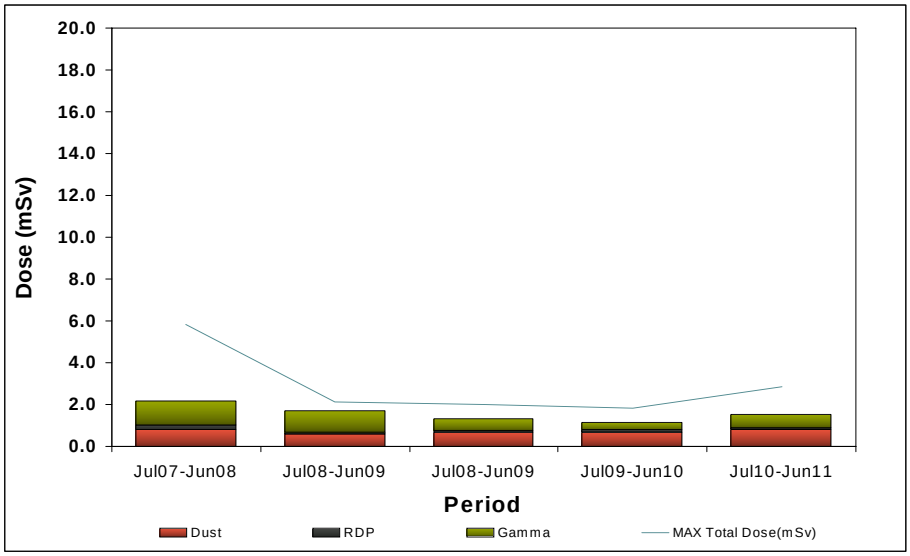


Figure 34 – Dose Trends for the Concentrator Workgroup

Hydromet

The average and maximum dose for Hydromet workers decreased this reporting period. Lower dust exposures have been recorded in the precipitation and calciner areas which have seen the overall workgroup doses decrease.

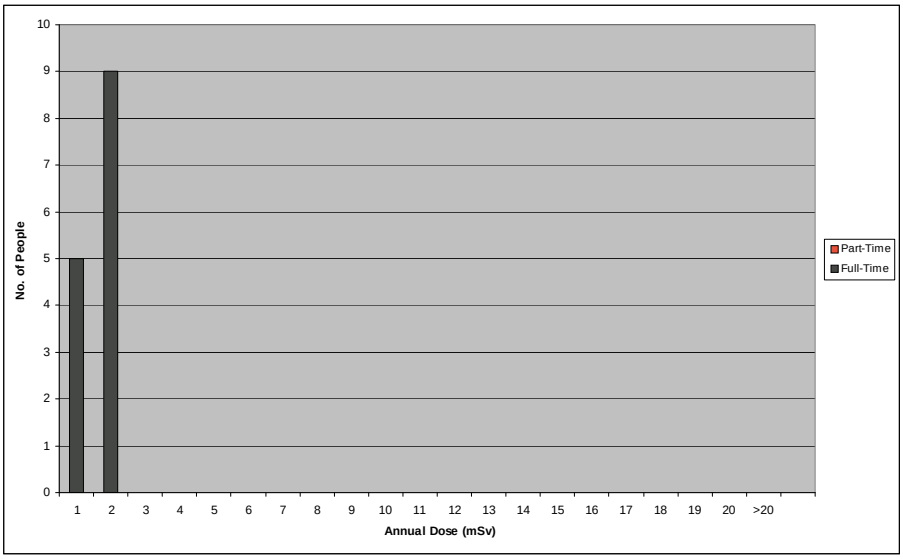


Figure 35 – Annual Dose Distribution for the Hydromet Workgroup

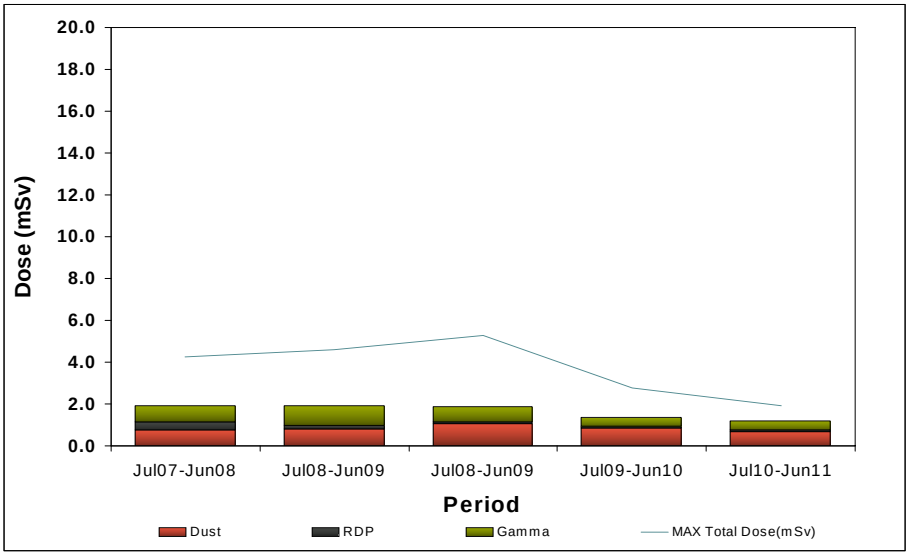


Figure 36 – Dose Trends for the Hydromet Workgroup

Smelter

Average doses in the smelter increased to 3.0 mSv from 1.8 mSv following return to normal smelting rates. Maximum dose increased from 3.6 mSv to 6.4 mSv with the 90th percentile dose increasing to 5.5 mSv. Polonium 210 (Po210) activity concentrations in key smelter inputs and outputs was closely monitored during the year to ensure it would not reach activity concentrations that would adversely impact on dust exposures. The better understanding of Po210 behaviour has allowed for higher levels of dust to be recycled and at the same time reduce exposures.

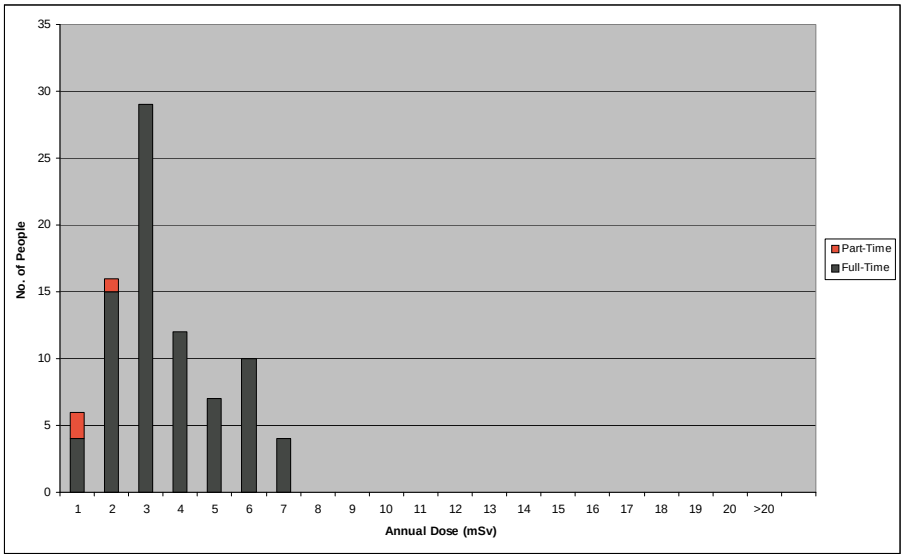


Figure 37 – Annual Dose Distribution for the Smelter Workgroup

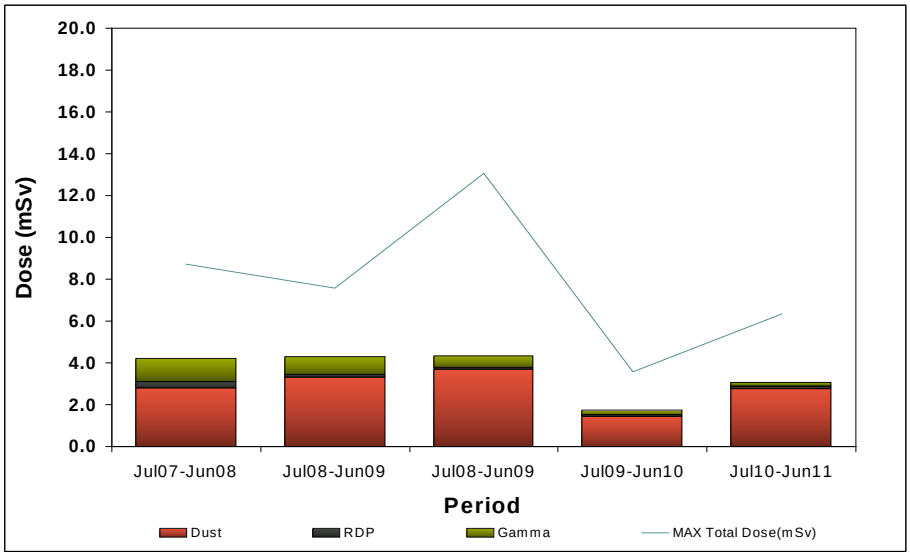


Figure 38 – Dose Trends for the Smelter Workgroup

Refinery

The Refinery workforce recorded the lowest maximum and annual average of any designated workgroup in the Metallurgical Plant, and remains at less than 1mSv.

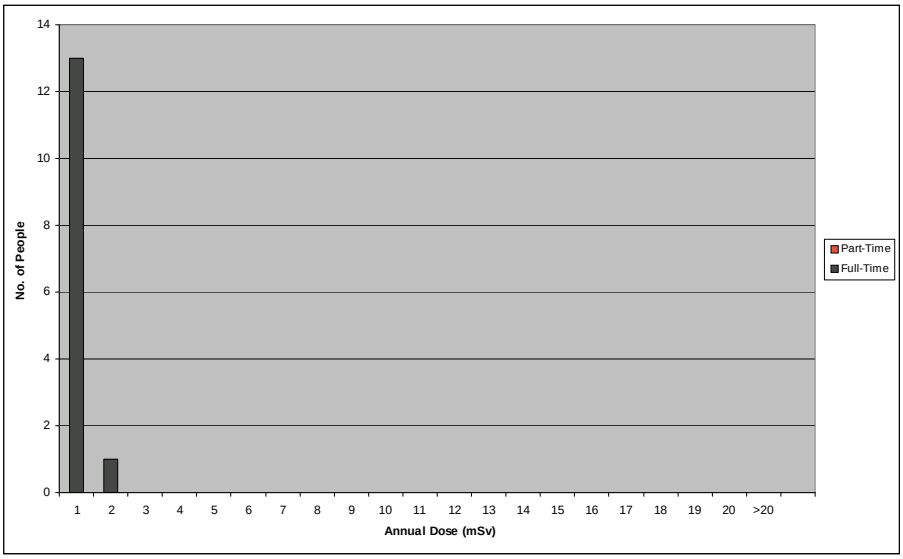


Figure 39 – Annual Dose Distribution for the Refinery Workgroup

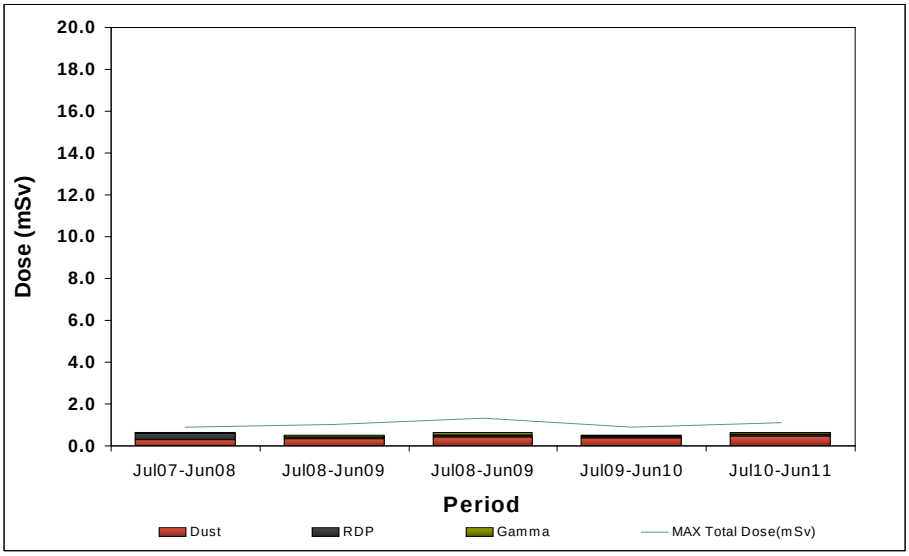


Figure 40 – Dose Trends for the Refinery Workgroup

Maintenance/ Services

The variable nature of the maximum dose is due to the fact that some of these personnel are spending time both underground and in the smelter building. The annual average dose decreased from 1.2 mSv to 1.1 mSv.

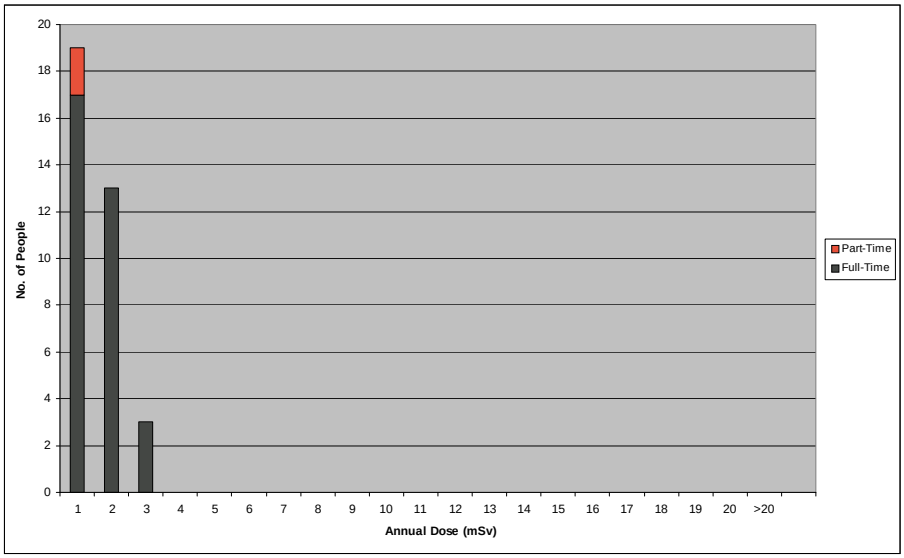


Figure 41 – Annual Dose Distribution for the Maintenance/Services Workgroup

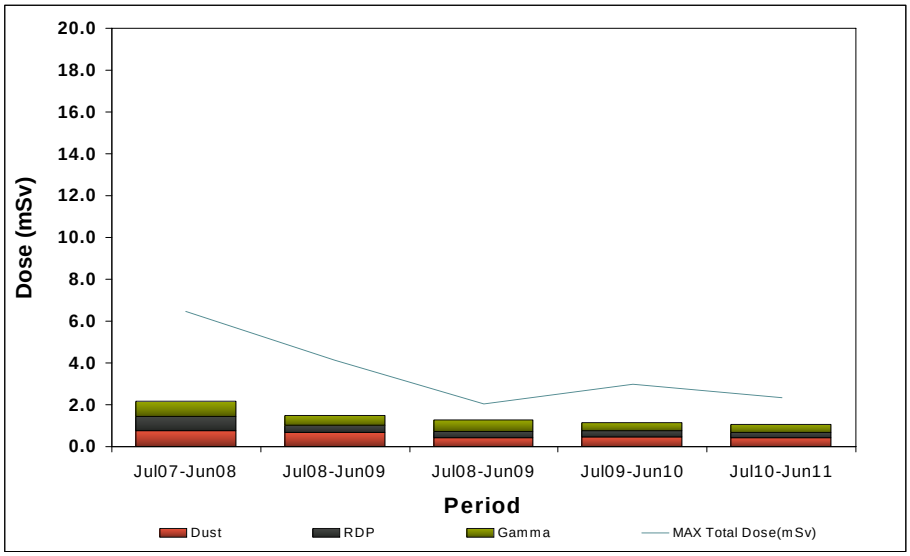


Figure 42 – Dose Trends for the Maintenance/Services Workgroup

Slag Handling

The average and maximum dose to the Slag Handling workgroup has decreased due to lower dust exposures being received by the group.

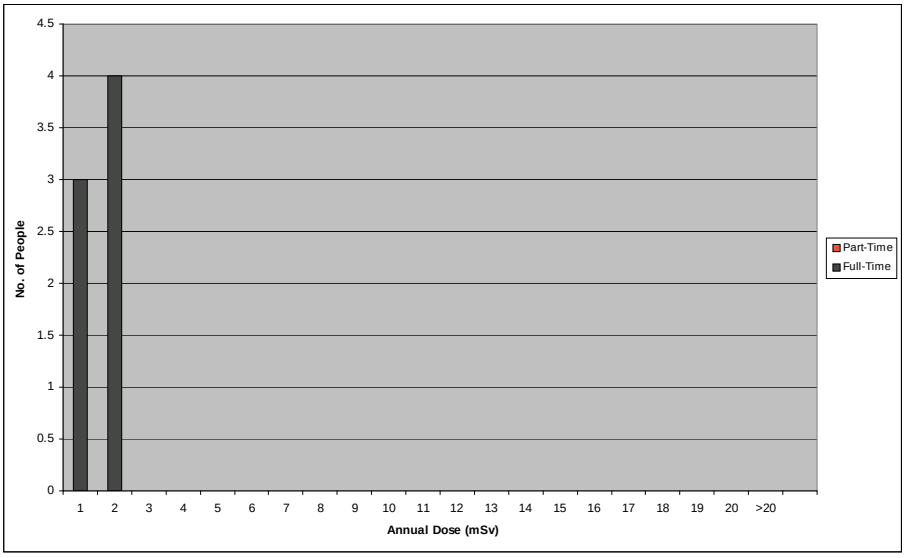


Figure 43 – Annual Dose Distribution for the Smelter Slag Handling Workgroup Dose Histogram

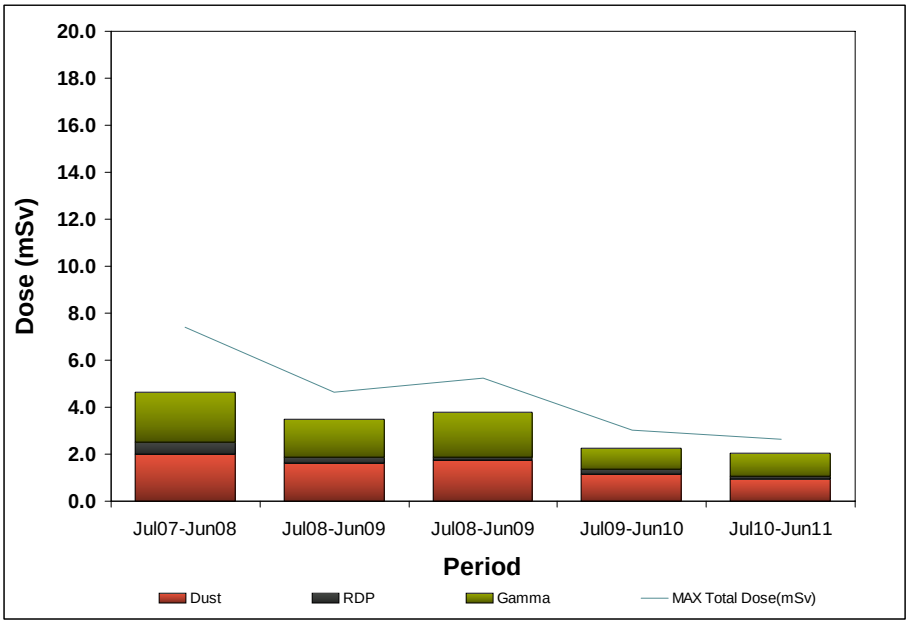


Figure 44 – Dose Trends for the Smelter Slag Handling Workgroup

3.2.3 Strategies for Dose Reduction

The smelter has achieved a significant result this year as it has been able to smelt at pre Clark Shaft incident production levels but with lower radiation doses.

Both the smelter and concentrator team have increased assay frequency of key process streams such as dust leach, concentrate leach and the smelter furnace inputs and outputs in order to maintain control of Po210 throughout the system. Most of the Po210 control is achieved at the smelter by varying the amount of waste heat boiler and electrostatic precipitator dust recycled directly to the flash furnace. However the dust that is bled to the concentrator also needs to be monitored to ensure that the dust is sufficiently leached of Po210, otherwise the Po210 will return to the smelter through the feed concentrate.

In March 2011 the Radiation & Occupational Hygiene Technicians were placed on a 4/5 day shift roster. This has provided better surface coverage. At the same time the Smelter Project also came under the responsibility of the Radiation & Occupational Hygiene department and the contractor position was converted into a fulltime role across both shifts. This additional support at the Smelter ensures that monitoring programs in that area exceed those required by the approved Radiation Management Plan.

3.2.4 Doses to Non-Designated Employees

Doses to the most exposed non-designated Metallurgical Plant employees have been assessed. The current time/location system collects information from the majority of BHP Billiton Olympic Dam employees and contractors on site. Only a small fraction of these workers are designated. The rest are classified as non-designated workers, however, their doses are assessed using the same dose calculation system as for designated employees. A summary of dose statistics is given in Table G.

Table G – Non-Designated Employees Metallurgical plant, Dose Statistics

Statistics	Non Designated Employees
Count	2157
Arithmetic Mean (mSv)	0.8
90th Percentile (mSv)	1.4
Min (mSv	0.1
Max (mSv)	2.7
Mean % Dose from RDP.	10%
Mean % Dose from Dust	48%
Mean % Dose from Gamma	42%

The total number of non-designated employees increased from 2143 in the 2009/2010 year to 2157 in the 2010/2011 year.

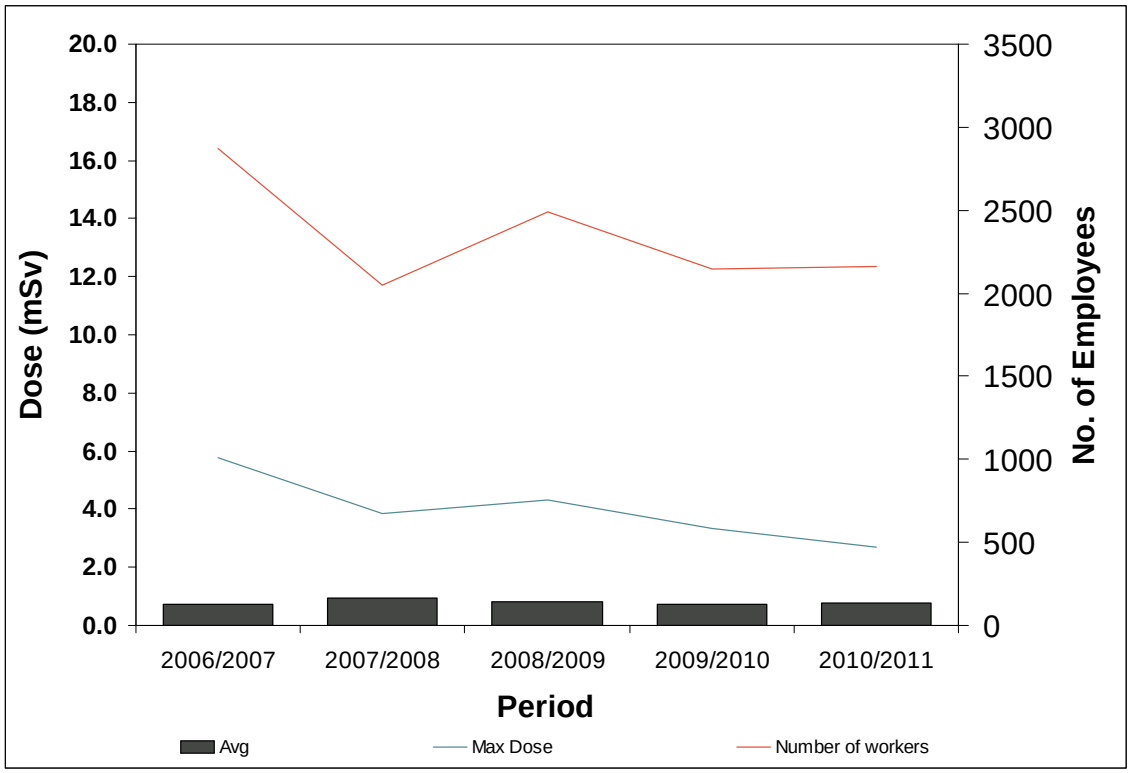


Figure 45 – Average Dose to Non-designated Metallurgical Plant Employees

The average dose has increased to 1.0 mSv from 0.7 mSv in 2009/2010. The 90th percentile has remained at 1.4 mSv. The highest recorded dose for a non-designated employee was 2.7 mSv. This employee is a contractor maintenance technician who is working in the smelter maintenance team.

The distribution of doses for 2010/2011 non-designated Metallurgical Plant employees is given in Figure 46.

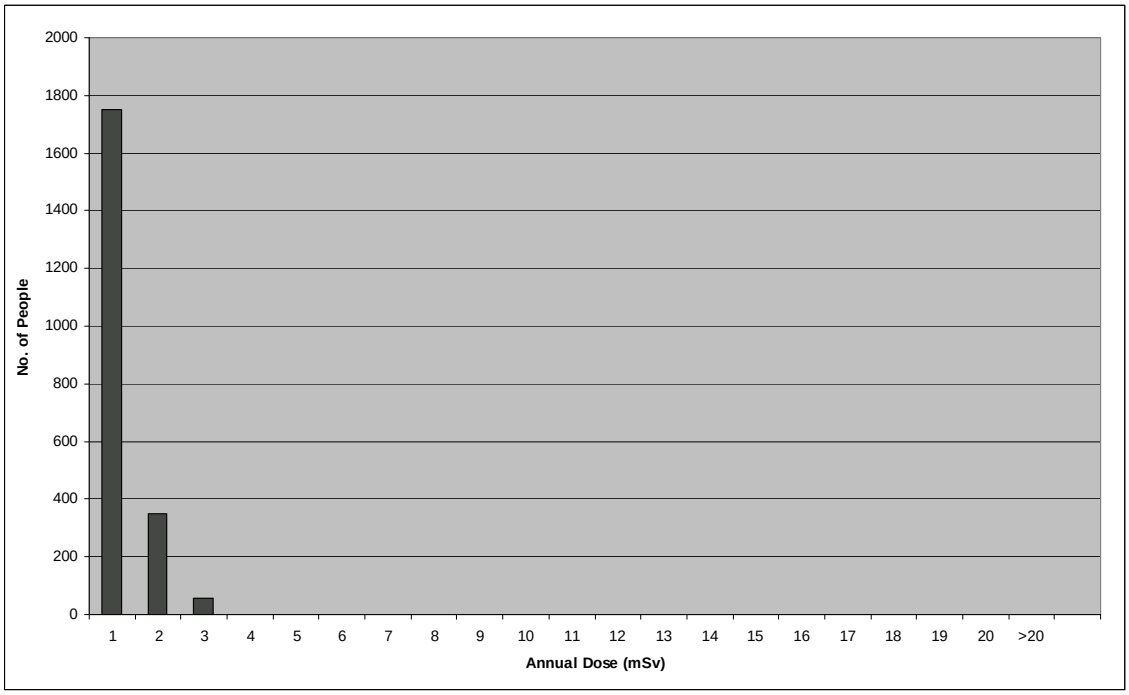


Figure 46 – Annual Dose Distribution for Non-designated process plant employees

Dose statistics for non-designated employees working in the Metallurgical Plant areas are shown in Table H and Figure 47.

Table H – Dose Statistics For non-designated Plant employees

WORK CATEGORY	No. of Emp.	Mean (mSv)	Minimum (mSv)	Maximum (mSv)	Standard Deviation (mSv)
Concentrator	132	1.1	0.5	2.2	0.4
Hydromet	106	1.2	0.4	2.3	0.4
Smelter	154	1.5	0.3	2.7	0.6
Refinery	107	0.7	0.3	2.3	0.3
Services/Maintenance	1658	0.7	0.1	2.6	0.3

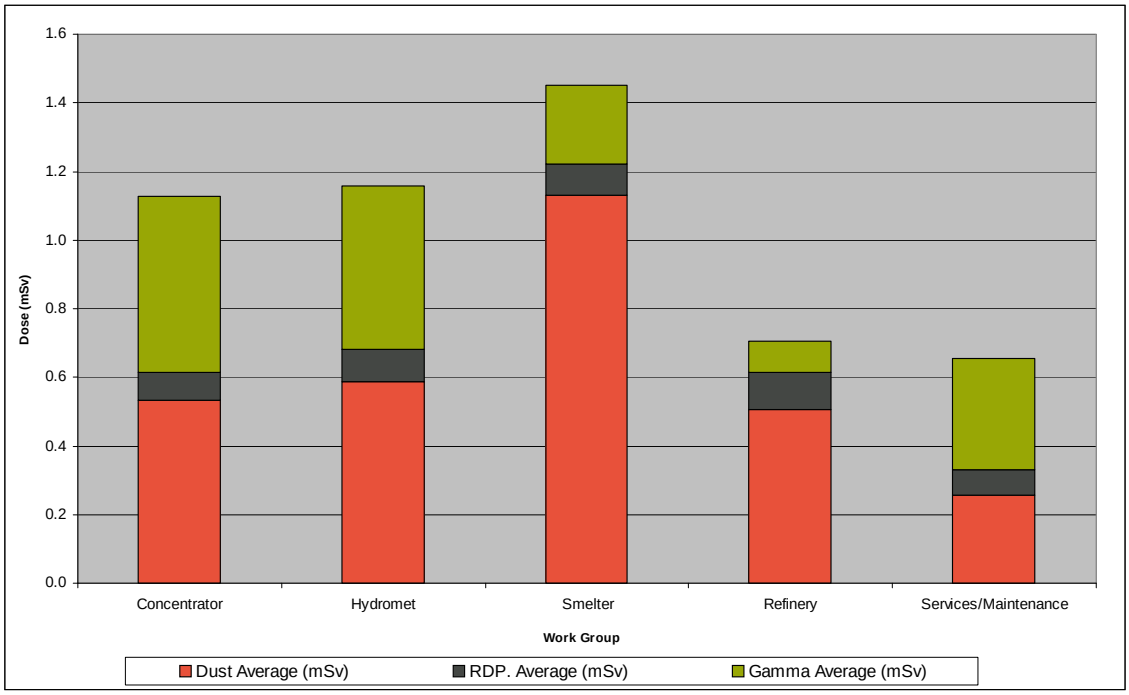


Figure 47 – Non Designated Process plant dose break-up, by workgroup

Airborne dust doses and radon decay product doses have been calculated using average airborne dust measurements, average positional radon decay product measurements and the relevant dose conversion factors. Gamma doses have been estimated based on direct personal monitoring and averages resulting from this monitoring. Hours are recorded by actual hours as recorded by Prodtrak, SAP, and the Cardax system. The Refinery and services/maintenance workgroups continued to record an average dose below 1 mSv during 2010/2011.

3.2.5 Cumulative Five Year Dose

As outlined in ICRP 103, the total dose of any individual radiation worker should not exceed 100 mSv in any five year period. To this end, a five year total dose has been determined for all Metallurgical Plant employees who were employed at BHP Billiton Olympic Dam for the previous five years. Designated employees who have worked for more than 18 quarters are included in this analysis.

There were a total of 448 currently designated Metallurgical Plant employees who worked continuously at Olympic Dam during the period 1 July 2006 to 30 June 2011.

The maximum dose for the five year period was 32.5 mSv, compared to the value of 32.4 mSv calculated in 2009/2010. The arithmetic mean for the five year dose period for the Metallurgical Plant has decreased from 8.3 mSv to 7.6 mSv. The distribution of doses for the cumulative five year dose is shown in Figure 48.

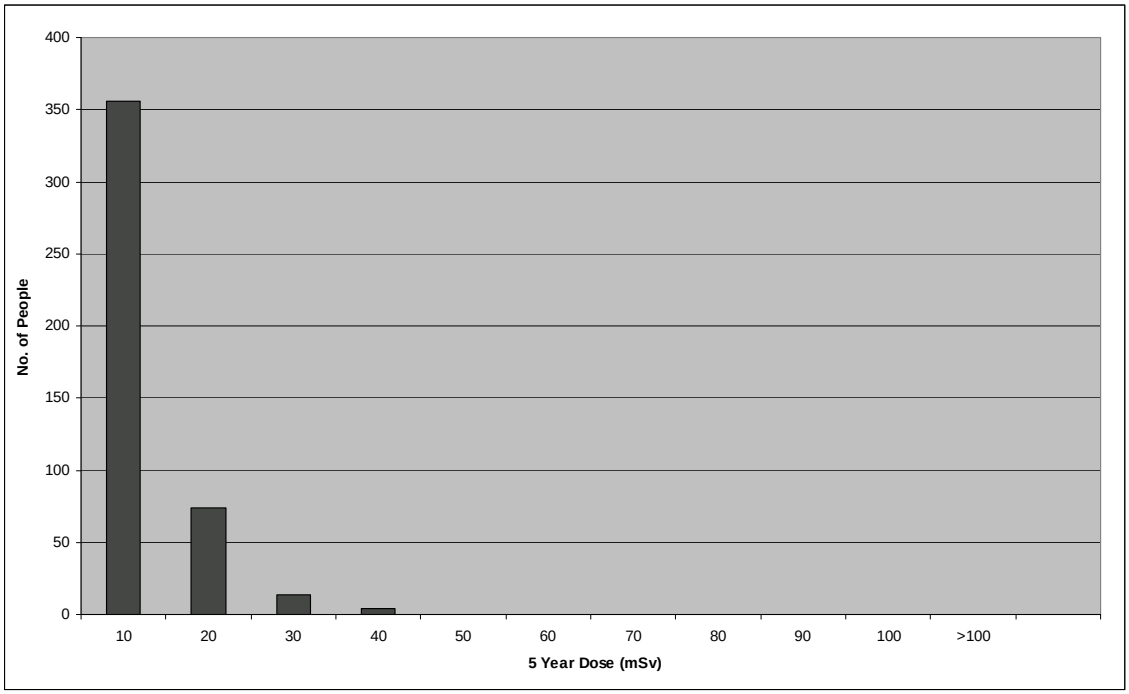


Figure 48 – 5 Year Cumulative Dose Distribution for Process Plant Employees

A summary of the cumulative five year dose is given in Table I below.

Table I – Five Year Dose Statistics

Statistics	Cumulative 5 year Doses	Equivalent Average yearly Dose
	For Continuously Employed Designated Plant Employee	
Count	448	448
Arithmetic Mean (mSv)	7.6	1.5
90th Percentile (mSv)	14.5	2.9
Min (mSv	2.1	0.4
Max (mSv)	32.5	6.5
Mean % Dose from RDP	12%	
Mean % Dose from Dust	74%	
Mean % Dose from Gamma	28%	

3.3 Annual Dose Trends

The average total effective dose to all designated employees at the Mine and Metallurgical Plant since 2006/2007 are shown in Figure 49 and Figure 50 respectively. The annual dose for the last year has been dominated by radon decay product exposure in the Mine and by dust exposure in the Process Plant, in particular, due to polonium-210 in the Smelter.

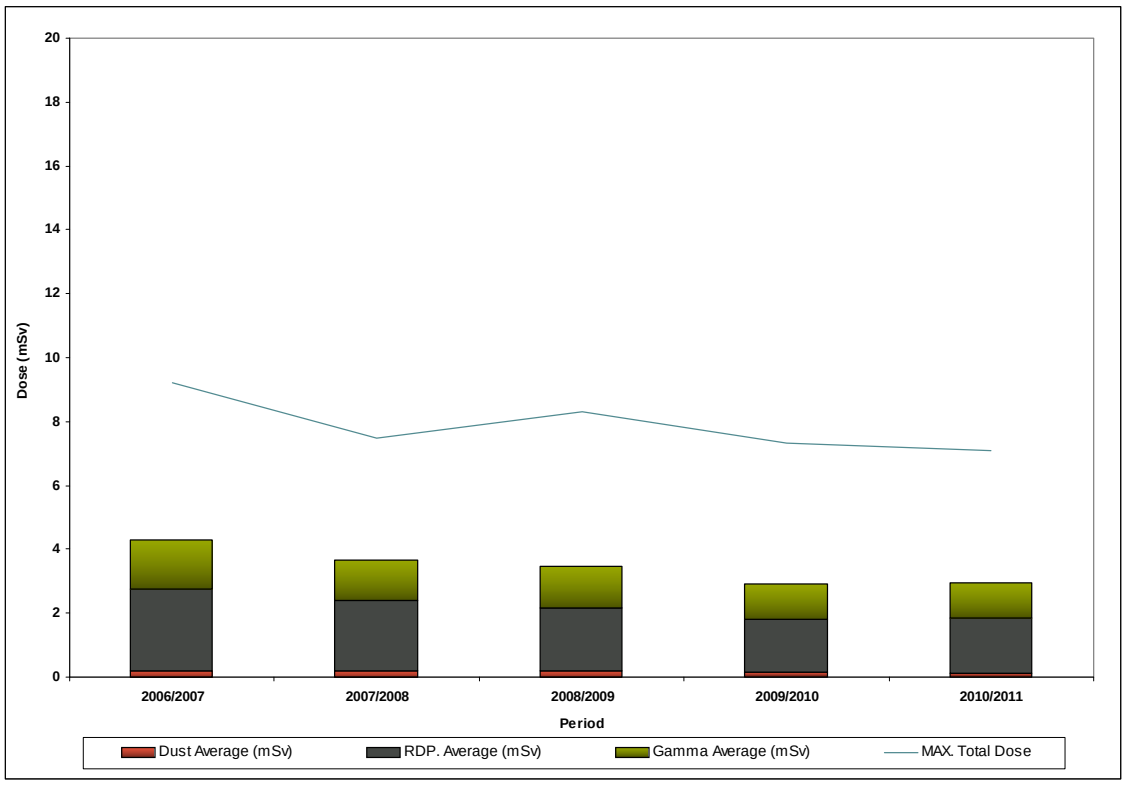


Figure 49 – Mine Annual dose trend

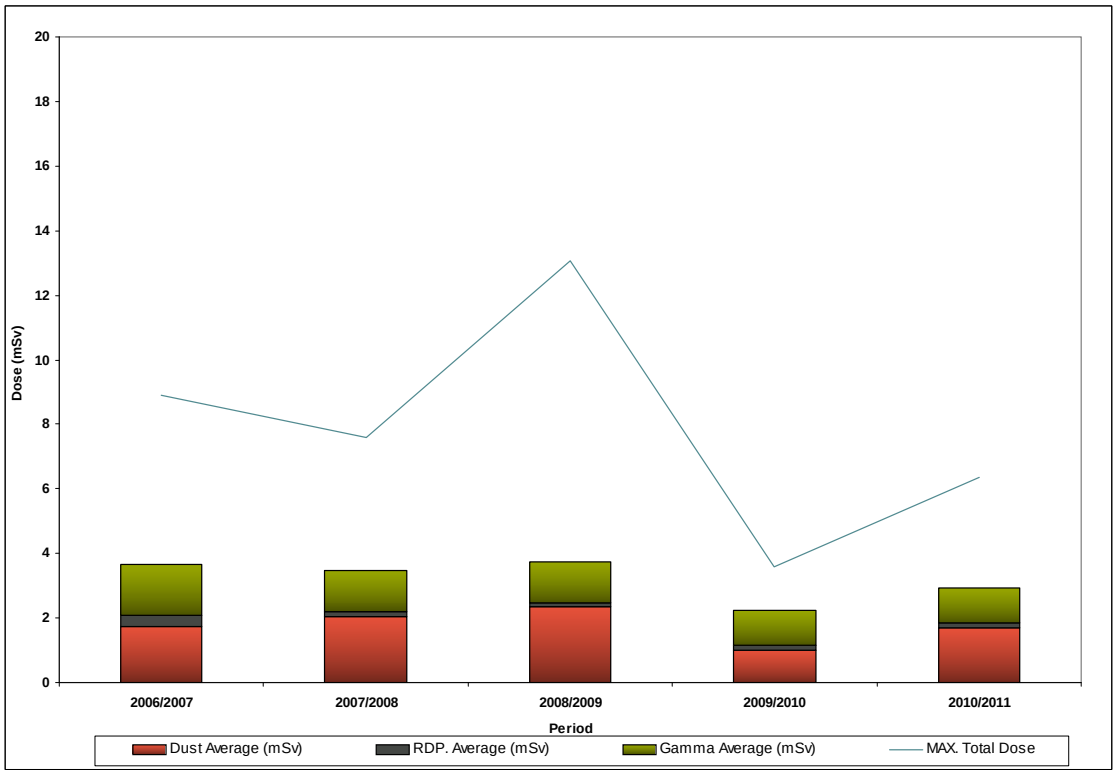


Figure 50 – Plant Annual Dose Trend

3.4 Doses to Members of the Public

The full assessment of doses to members of the public will be presented separately in the Environmental Management and Monitoring Report.

For all members of the public, the effective dose from the operation, for the period July 2010 to June 2011 was well below the statutory limit of 1 mSv per annum. Estimated maximum operational related doses are shown in Table J.

Table J – Public Doses

2010/2011 dose to Members of the Public living at	Dose (mSv)	Dose Limit (mSv)
Roxby Downs	0.008	1
Olympic Dam Village	0.009	1

Figure 51 presents the public dose trends for Olympic Dam Village and Roxby Downs since 1991. The frequent rainfall throughout FY11 resulted in lower doses being received from the PM10 dust component of dose. The FY11 dose to the members of the public has continued to remain below the minimum detection limit of 0.048 mSv.

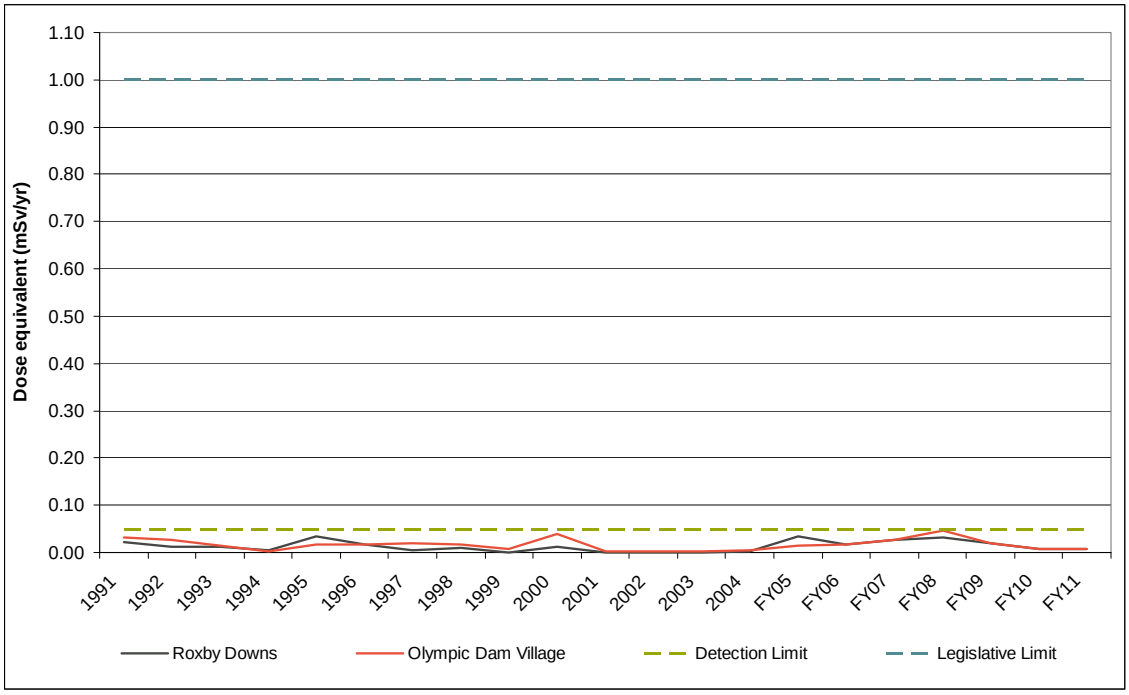


Figure 51 – Total Dose Trend for Olympic Dam Village and Roxby Downs

APPENDIX A

Dose Conversion Factors 2010/2011

A summary of the airborne dust dose conversion factors for specific work areas can be viewed in the following table.

Table K – Dust Dose Conversion Factors

Location	DCF (µSv.m3/Bq.hr)
Smelter	7.5
Refinery / STP	5.4
SX / Precipitation / Calciners	4.5
Other*	4.1

*All other areas of Mine, Concentrator, Slag Concentrator, Hydromet and Services (Laboratories and Metallurgical Workshop)

The default RDP dose conversion factor used was 1.41 mSv.m3/mJ.hr (5 mSv/WLM).