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ALCOHOL AND DRUG TESTING IN WASTEWATER:
Summary Results from August 2016 Testing in Melbourne and
Regional Victoria

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October 2017

easternhealth



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Alcohol and Drug Wastewater Project is a collaboration between Turning Point and the University of Queensland, and is jointly funded by Victoria Police and the Victorian Department of Health and Human Services



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Contents

Preface	7
Acknowledgments.....	8
Key Points.....	9
Introduction	11
Aims	11
Methods.....	11
Sampling.....	11
Analytical method	11
Drug Measurement.....	12
Treatment Plants and Catchment Population	12
Results.....	13
Metropolitan Melbourne	13
August 2016	13
Comparison between March 2015 and June 2015	14
Comparison between March 2015 and May 2016	14
Comparison between March 2015 and August 2016	15
Comparison between March 2014 and March 2015	15
Regional Victoria	16
Regional Site 1 – August 2016.....	16
R1 – comparison between June 2015 and August 2016.....	16
Regional Site 2 – August 2016.....	17
R2 – comparison between July/August 2015 and May 2016	17
R2 – comparison between July/August 2015 and August 2016	17
Regional Site 3 –August 2016	18
R3 – comparison between June 2015 and June 2016.....	18
R3 – comparison between June 2015 and August 2016.....	18
Summary	27
Context.....	28
Limitations	29
References	31
Appendix 1	32
Appendix 2	33
Appendix 3	34

List of Tables

Table 1: Time points for sample collection at different locations	9
Table 2: Population estimates (in 100,000) for treatment plants across testing phases	12
Table 3: List of analytical methods of alcohol and other drug testing for wastewater	12
Table 4: Estimated mean alcohol, tobacco and illicit drug consumption using wastewater analysis at treatment plants in Melbourne, August 2016	19
Table 5: Estimated mean alcohol, tobacco and illicit drug consumption using wastewater analysis at treatment plants in R1, August 2016	20
Table 6: Estimated mean alcohol, tobacco and illicit Drug consumption using wastewater analysis at treatment plants in R2 and R3, August 2016	21

List of Figures

Figure 1: Estimated mean cocaine consumption using wastewater analysis at treatment plants in Melbourne and Regional Victoria, Mar 2014, Mar/Jun/Jul 2015, May 2016, Aug 2016	22
Figure 2: Estimated mean methamphetamine consumption using wastewater analysis at treatment plants in Melbourne and Regional Victoria, Mar 2014, Mar/Jun/Jul 2015, May 2016, Aug 2016	23
Figure 3: Estimated mean MDMA (ecstasy) consumption using wastewater analysis at treatment plants in Melbourne and Regional Victoria, Mar 2014, Mar/Jun/Jul 2015, May 2016, Aug 2016	24
Figure 4: Estimated mean cigarette consumption using wastewater analysis at treatment plants in Melbourne and Regional Victoria, Mar 2014, Mar/Jun/Jul 2015, May 2016, Aug 2016	25
Figure 5: Estimated mean alcohol consumption using wastewater analysis at treatment plants in Melbourne and Regional Victoria, Mar 2014, Mar/Jun/Jul 2015, May 2016, Aug 2016	26

List of Equations

Equation 1: The calculation used to the daily drug consumption of a target drug per 1000 people per day	11
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List of Appendices

Appendix 1: Estimated mean Alcohol, Tobacco and Illicit Drug consumption using wastewater analysis at treatment plants in Melbourne, March 2015, June 2015, May 2016	32
Appendix 2: Estimated mean Alcohol, Tobacco and Illicit drug consumption using wastewater analysis at treatment plants in R1, June 2015	33
Appendix 3: Estimated mean Alcohol, Tobacco and Illicit drug consumption using wastewater analysis at treatment plants in R2 (July/August 2015, May 2016) and R3 (June 2015, May/June 2016)	34

Preface

This examination of alcohol and drug contaminants in wastewater is a collaborative project between Turning Point's Population Health Research team and the University of Queensland National Research Centre for Environmental Toxicology (Entox), and is funded by the Victoria Police and the Victorian Department of Health and Human Services.

Turning Point is a specialist alcohol and other drug organisation that integrates treatment and support services with research, education and training. This unique service model ensures that research informs clinical practice and vice versa, resulting in a best practice environment.

Turning Point amalgamated with public health provider Eastern Health in October 2009 and is formally affiliated with Monash University. Turning Point is part of the International Network of Drug Treatment and Rehabilitation Resource Centres for The United Nations Office of Drugs and Crime and is a member of the International Harm Reduction Association.

Turning Point strives to promote and maximise the health and wellbeing of individuals and communities living with and affected by alcohol and other drug-related harms. We aspire to be a world-leading service delivery and research and development centre.

To achieve this, we are continually:

- creating thriving service delivery, research and development cultures that produce the best possible knowledge;
- applying, using and translating this knowledge to promote change, build effective and rational policy, and demonstrate and contribute to world's best practice;
- building our own and our communities' capacity through strategic relationships, partnerships and collaborations;
- strengthening organisational capacity to provide the best environment for quality staff to achieve their potential.

Since being established in 1994, Turning Point has led research and its translation into policy and practice at a local, national and international level. To best respond to emerging issues, Turning Point employs staff from a range of professional backgrounds and collaborates with organisations across the research, health, education and community services sectors.

The organisation integrates activities across a diverse range of specialist knowledge and professional practice. This unique combination enables Turning Point to translate evidence into action. Our work is essential to understanding the complexities of alcohol and other drug use in our community and in developing effective approaches to prevent and treat dependence and other related harms.

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We would like to thank staff from the University of Queensland National Research Centre for Environmental Toxicology (Entox) for organising the sampling from each water treatment plant, conducting the testing and analysis and providing the results. We would also like to thank the water treatment plants in Metropolitan and Regional Victoria for allowing us to collect water samples prior to treatment.

This project was jointly funded by Victoria Police and the Victorian Department of Health and Human Services.

Key Points

This report provides results from the August 2016 wastewater testing completed in metropolitan Melbourne and regional Victoria. Comparisons are made between the first wave of wastewater testing and the waves following that. Table 1 provides a summary of the time points when wastewater testing was carried out at different treatment plants.

TABLE 1: TIME POINTS FOR SAMPLE COLLECTION AT DIFFERENT LOCATIONS

Melbourne (2 sites)	Regional 1 (R1) (3 sites)	Regional 2 (R2) (1 site)	Regional 3 (R3) (1 site)
Aug 2016	Aug 2016	Aug 2016	Aug 2016
May 2016	Jun 2015	May 2016	May/Jun 2016
Jun 2015		Jul/Aug 2015	Jun 2015
Mar 2015			
Mar 2014			

Cocaine mean consumption levels:

- in metropolitan Melbourne, increased 30% between March 2014 and March 2015, decreased by 21% between March 2015 and June 2015, and remained stable between June 2015 and May 2016. Consumption then increased 11% between May 2016 and August 2016.
- when compared to metropolitan Melbourne in August 2016, approximately 64% lower in R1, 86% lower in R2, and 74% lower in R3.
- increased by 211% in R1 between June 2015 and August 2016
- in R2 remained stable between July 2015 and May 2016, and increased 83% between May 2016 and August 2016.
- in R3 increased 26% between June 2015 and June 2016, and then increased 58% between June 2016 and August 2016

Methamphetamine mean consumption levels:

- in metropolitan Melbourne, almost doubled between March 2014 and March 2015, remained almost same between March 2015 and June 2015, and then increased 27% between June 2015 and May 2016. Consumption then decreased 14% between May 2016 and August 2016.
- in August 2016, approximately 22% higher in R1, 4% lower in R2 and 148% higher in R3, than metropolitan Melbourne
- increased approximately 93% in R2 between July 2015 and May 2016, then decreased 40% between May 2016 and August 2016
- decreased 17% in R3 between June 2015 and June 2016 and again decreased 20% between June 2016 and August 2016
- in R1 approximately 55% higher in August 2016 compared to June 2015.

MDMA (ecstasy) mean consumption levels:

- in metropolitan Melbourne, decreased 10% between March 2014 and March 2015, then remained almost the same until June 2015, and increased 79% between June 2015 and May 2016. Consumption then almost halved between May 2016 and August 2016.
- in metropolitan Melbourne approximately 67% higher than in R1, 50% higher than in R2 and 74% higher than in R3, in August 2016
- increased 50% in R2 between July 2015 and May 2016, and then decreased 61% between May 2016 and August 2016
- decreased 17% in R3 between June 2015 and June 2016, and then decreased 52% between June 2016 and August 2016
- in R1 decreased 24% between June 2015 and August 2016

Tobacco mean consumption levels:

- in metropolitan Melbourne remained stable between March 2014 and March 2015, then decreased 17% between March 2015 and June 2015, and then decreased 21% between June 2015 and May 2016. Consumption then increased 15% between May 2016 and August 2016.
- in August 2016, 22% higher in R1, 28% higher in R2, and more than double in R3, compared to metropolitan Melbourne
- remained stable in R2 between July 2015 and May 2016, and decreased 32% between May 2016 and August 2016
- decreased 64% in R3 between June 2015 and June 2016, and increased 12% between May 2016 and August 2016
- in R1 decreased 29% between June 2015 and August 2016

Alcohol mean consumption levels:

- in metropolitan Melbourne, increased 13% between March 2014 and March 2015, and then decreased 20% between March 2015 and June 2015. Consumption remained stable between June 2015 and May 2016, and between May 2016 and August 2016.
- in August 2016, 23.5% higher in R1, 9% higher in R2, and 56% higher in R3, compared to metropolitan Melbourne
- increased 52% in R2 between July 2015 and May 2016, and decreased 47% between May 2016 and August 2016
- decreased 46% in R3 between June 2015 and June 2016 and decreased 19% between May 2016 and August 2016
- in R1 remained stable between June 2015 and August 2016

Introduction

Substance misuse can result in a range of social harms, including impacts on community safety and the resources of service providers, including police, health and emergency services [1]. Estimating the use of alcohol and drugs in the community is important for law enforcement agencies, health and emergency services. Australia has four ongoing drug monitoring systems, including the AIC's DUMA program, the National Drug Strategy Household Survey, the Illicit Drug Reporting System and the Ecstasy and Related Drug Reporting System. The systems vary in methods, but broadly they are reliant upon self-report data and may be subject to selection biases [2].

Chemists can now quantify a wide variety of substances in wastewater (i.e. sewage) including those associated with illicit drug consumption [2]. This method has been used to measure drug use in Europe, North America and Australia [3, 4].

This summary report provides results from the fourth wave of testing in Melbourne, the second wave in regional site 1 (R1) and the third wave results in regional site 2 (R2) and regional site 3 (R3).

Aims

The objective of this research is to determine the level of contaminants discharged in municipal wastewater treatment plants to estimate consumption levels in Melbourne and Regional Victoria during one week in August 2016.

Methods

Sampling

Raw wastewater samples were collected at the same time each day at the inlet of each sewage treatment plant during the week 5 August 2016 to 11 August 2016 in Melbourne, R1 and R2 and during the week 8 August 2016 to 13 August 2016 in R3.

Analytical method

Using a validated analytical method [4], the concentrations of cocaine, methamphetamine, and MDMA were measured in the samples. A back-calculation method employed in the literature [5, 6] was applied to the samples.

Consumption data (as expressed by mg/day/person) is back-calculated by the equation established and detailed by Zuccato et al. (2008) and is shown below.

EQUATION 1: THE CALCULATION USED TO THE DAILY DRUG CONSUMPTION OF A TARGET DRUG PER 1000 PEOPLE PER DAY.

$$\text{Daily drug consumption} \left(\frac{\text{mg}}{\text{day}} \right) = \frac{C_i \cdot F \cdot \frac{R_i}{E_i}}{P}$$

There are three key steps in this back calculation:

- 1) the mass load of a drug residue was obtained through multiplying its concentration (C_i) by the daily wastewater volume (F);

- 2) this amount was corrected by the average molar excretion factor (R_i / E_i) to back-calculate the amount of drug consumed;
- 3) the estimate was normalised to the catchment population (P) to allow per capita comparison of data across different locations.

Drug Measurement

When an illicit drug is consumed it passes into the bloodstream, exerts its effect upon the body and is then excreted in urine, faeces, saliva and sweat [2]. Most drugs are excreted within a few hours with the exception of THC [7]. Among the chemicals excreted is the unchanged or 'parent' drug. Most drugs also undergo metabolism, which is some form of alteration as a result of action by the body's enzymes (usually in the liver) and are called metabolites [2]. Like parent drugs, metabolites are also excreted (in urine, faeces etc.), and chemical analysis is completed to quantify the levels of parent drugs and metabolites in wastewater samples [2]. These levels and the average excretion values are used to back-calculate the estimated total consumption of particular drugs in the population [2]. Comparisons between the parent drugs and metabolites are used in wastewater analysis to eliminate the possibility of the detected levels being due to dumping of illicit drugs in sewers. If the metabolite loadings were significantly lower than the parent drug loadings, then this would indicate possible dumping or chemical run-off rather than drug consumption. The present study found agreement between the parent and metabolites, thereby indicating true consumption estimates.

Treatment Plants and Catchment Population

Table 2 lists the catchment population estimates for each treatment plant for different phases of data collection.

TABLE 2: POPULATION ESTIMATES (IN 100,000) FOR TREATMENT PLANTS ACROSS TESTING PHASES

Phases	Melbourne		R1			R2	R3
	Site 1	Site 2	A	B	C		
Aug-16	24	18	1.96	0.11	0.4	1.1	0.4
May-16*	21.3	16	-	-	-	0.93	0.4
Jun-15**	21.3	16	1.96	0.12	0.4	0.93	0.4
Mar-15	21.3	16	-	-	-	-	-

*Jun-16 for R1 and May/Jun-16 for R3. **Jul/Aug-15 for R2.

Table 3 provides a list of testable alcohol and drug (AOD) substances and the methods used.

TABLE 3: LIST OF ANALYTICAL METHODS OF ALCOHOL AND OTHER DRUG TESTING FOR WASTEWATER

Method	No of Analytes	Key drugs covered
1. Main drugs – direct injection	19+	Cocaine, Methamphetamine, MDMA (ecstasy)
2. Alcohol – direct injection	2	Alcohol
3. Tobacco – direct injection	3	Tobacco

Results

This summary report provides findings from the fourth round of wastewater testing, which included several treatment sites in metropolitan Melbourne and regional Victoria in August 2016. It also shows a comparison of results from the first wave (March 2015) with results from each of the following waves. Please note that data were first collected for metropolitan Melbourne in March 2015 and for regional sites in May/June 2015.

When mid-week and weekend consumptions for August 2016 testing are compared it appears that generally weekend consumption was higher than mid-week consumption for all of the substances except alcohol. In relation to cocaine and MDMA consumption, this finding is in line with the outcome from a nation-wide wastewater analysis study conducted in Australia [8]. This study showed that cocaine and MDMA consumption during weekdays was significantly lower than that on weekends.

However, findings from August 2016 contrast with the May/June 2016 wave outcome where weekend consumption appeared to be lower than the average mid-week consumption—unlike the previous two phases—for most of the drugs across all sites. The only exception was methamphetamine consumption in R2 and R3. A further investigation of consumption level on different days of the week for the May/June wave revealed that consumption level was generally highest on Mondays for all the drugs and sites.

From the data available for May/June 2016, we cannot explain why this increase in average consumption during mid-week compared to that during weekend might have occurred. It can only be predicted that a relatively higher level of consumption on weekend nights compared to early/mid-week has resulted in an increase in the Monday readings, and consequently in the average mid-week consumption figures.

Metropolitan Melbourne

August 2016

Table 4 and Figures 1-5 show the estimated mean alcohol, tobacco and illicit drug consumption from the two treatment plants. Overall in metropolitan Melbourne, the average consumption of cocaine, methamphetamine and MDMA (ecstasy) for the week 5-11 August 2016 was 224.5, 999.2 and 258.4mg/day/1000ppl respectively (Table 4). The average consumption of alcohol in August 2016 in metropolitan Melbourne was 12.4L/day/1000ppl and the average number of cigarettes/day/1000pl was 1413.7 (Table 4).

In Melbourne-Site 1 catchments, during the week, there was a mean consumption of 279.9, 1143.7 and 267.6mg/day/1000ppl of cocaine, methamphetamine and MDMA respectively (Table 4, Figure 1, Figure 2, Figure 3). On the weekend this changed to a mean consumption of 362.6, 1020.7 and 336.0mg/day/1000ppl respectively (Table 4, Figure 1, Figure 2, Figure 3).

In Melbourne-Site 2 catchments, during the week, there was a mean consumption of 83.9, 857.5 and 219.8mg/day/1000ppl of cocaine, methamphetamine and MDMA respectively (Table 4, Figure 1, Figure 2, Figure 3). On the weekend this changed to a mean consumption of 207.3, 843.4 and 221.1mg/day/1000ppl respectively (Table 4, Figure 1, Figure 2, Figure 3).

For Site 1 and Site 2 catchments, the consumption of cigarettes during the week was estimated at 1593.6 and 1285.7/day/1000ppl, respectively (Table 4, Figure 4). However, on the weekend the mean consumption decreased to 1380.5/day/1000ppl in Melbourne-Site1 catchments and 1178.3/day/1000ppl in Melbourne-Site 2 catchments (Table 4, Figure 4).

For the Melbourne-Site 1 catchment, the consumption of alcohol decreased from 14.9L during the week to 14.1L/day/1000pl on the weekend (Table 4, Figure 5). In contrast, for the Site 2 catchment the average consumption increased from 8.7L mid-week to 11.4L/day/1000ppl on the weekend (Table 4, Figure 5).

Comparison between March 2015 and June 2015

The first round of wastewater testing was completed in March 2015 for metropolitan Melbourne [8]. The second round of wastewater testing was completed in June/July 2015 for metropolitan Melbourne and three regional Victorian sites [9].

Overall in metropolitan Melbourne, the average consumption of cocaine, methamphetamine and MDMA (ecstasy) for the week 24th-30th of June 2015 was 206.7, 920.3 and 271.9mg/day/1000pl respectively (Appendix 1). In Site 1 catchments, the average consumption of cocaine, methamphetamine and MDMA in June 2015 was 285.1, 984.6 and 358mg/day/1000ppl. In Site 2 catchments, the average consumption for these drugs was 102.5, 834.8 and 157.6mg/day/1000ppl, respectively (Appendix 1).

The average consumption of alcohol in June 2015 in metropolitan Melbourne was 10.9L/day/1000ppl and the average number of cigarettes/day/1000pl was 1555.3 (Appendix 1).

Overall in metropolitan Melbourne between March 2015 and June 2015, the consumption of all substances decreased. The consumption of cocaine decreased 21%, and MDMA and methamphetamine remained almost stable (Figure 1, Figure 2, Figure 3, Appendix 1). Alcohol consumption decreased 20% and tobacco consumption decreased 17% between March 2015 and June 2015 (Figure 4, Figure 5).

In Melbourne-Site 1 catchments, between March and June of 2015, cocaine decreased 22%, MDMA decreased 10% and methamphetamine consumption decreased approximately 15% (Figure 1, Figure 2, Figure 3, Appendix 1). In the same catchment site, both alcohol and tobacco consumption decreased approximately 20% (Figure 4, Figure 5, Appendix 1).

In Melbourne-Site 2 catchments, between March and June, MDMA and methamphetamine consumption increased 42% and 24%, respectively, yet cocaine consumption decreased 16% (Figure 1, Figure 2, Figure 3, Appendix 1). In Site 2 catchments, alcohol consumption decreased 20% and tobacco consumption decreased 11% (Figure 4, Figure 5, Appendix 1).

Comparison between March 2015 and May 2016

Overall in metropolitan Melbourne between March 2015 and May 2016, the consumption of cocaine decreased 23%, MDMA remained stable and methamphetamine increased 16% (Figure 1, Figure 2, Figure 3, Appendix 1). Alcohol consumption decreased 21% and tobacco consumption decreased 17% between March 2015 and May 2016 (Figure 4, Figure 5).

In Site 1 catchments, between March and May 2016, cocaine decreased 20%, but MDMA and methamphetamine consumption increased by 70% and 14%, respectively (Figure 1, Figure 2, Figure 3, Appendix 1). In the same catchment site, alcohol consumption remained stable and tobacco consumption decreased by 33% (Figure 4, Figure 5, Appendix 1).

In Site 2 catchments, between March 2015 and May 2016, cocaine decreased 35%, while MDMA and methamphetamine consumption increased by 115% and 20%, respectively (Figure 1, Figure 2, Figure 3, Appendix 1). In the same site, both alcohol and tobacco consumption decreased by around 35% (Figure 4, Figure 5, Appendix 1).

Comparison between March 2015 and August 2016

Overall in metropolitan Melbourne between March 2015 and August 2016, the consumption of cocaine decreased by 14%, MDMA increased by 78% and methamphetamine consumption remained almost the same (Figure 1, Figure 2, Figure 3, Appendix 1). Alcohol and tobacco consumption decreased 15% and 34%, respectively, between March 2015 and August 2016 (Figure 4, Figure 5, Appendix 1).

In Melbourne-Site 1 catchments, between March 2015 and August 2016, the consumption of cocaine and MDMA decreased 17%, 28%, respectively, and that of methamphetamine remained stable (Figure 1, Figure 2, Figure 3, Appendix 1). In the same catchment site, the consumption of alcohol remained almost the same but tobacco consumption decreased by 23% (Figure 4, Figure 5, Appendix 1).

In Melbourne-Site 2 catchments, between March 2015 and August 2016, cocaine and methamphetamine consumption stayed nearly the same whereas MDMA consumption almost doubled (Figure 1, Figure 2, Figure 3, Appendix 1). In the same site, both alcohol and tobacco consumption decreased by around 25% (Figure 4, Figure 5, Appendix 1).

Comparison between March 2014 and March 2015

Whilst March 2014 wastewater testing was not included in the scope of this project, the laboratory kindly provided these results for a comparison to the March 2015 round one sampling. Overall, in metropolitan Melbourne, between March 2014 and March 2015 cocaine consumption increased 30%, MDMA decreased approximately 10% and methamphetamine consumption increased 84% (Figure 1, Figure 2, Figure 3, Appendix 1). Alcohol consumption increased 13% and tobacco consumption remained stable (Figure 4, Figure 5, Appendix 1).

In Melbourne-Site 1 catchments, between 2014 and 2015, cocaine consumption remained stable and MDMA consumption decreased 13%, yet methamphetamine consumption increased almost 45% (Figure 1, Figure 2, Figure 3, Appendix 1). In the same catchment site, alcohol consumption decreased 11%, and tobacco consumption decreased 14% (Figure 4, Figure 5, Appendix 1). In Melbourne-Site 2 catchments, between 2014 and 2015, cocaine increased 75%; MDMA consumption decreased approximately 43% and methamphetamine consumption raised to slightly above double (Figure 1, Figure 2, Figure 3, Appendix 1). In Site 2 catchments, alcohol consumption increased 26% and tobacco consumption remained stable (Figure 4, Figure 5, Appendix 1).

Regional Victoria

Regional Site 1 – August 2016

Wastewater testing in R1 formed part of the fourth round of testing completed in August 2016. Overall in R1, the average mid-week consumption of cocaine, methamphetamine and MDMA for the week 5th-11th of August 2016 were 67.4, 1205.1 and 139.2mg/day/1000ppl (Table 5, Figure 1, Figure 2, Figure 3). On the weekend the estimated consumption increased to 114.7, 1257.3 and 216.2mg/day/1000ppl respectively (Table 5, Figure 1, Figure 2, Figure 3). The average number of cigarettes consumed in R1 was 1518.8/day/1000ppl mid-week and 1456.8/day/1000ppl on the weekend (Table 5, Figure 4). The mean consumption of alcohol in R1 was 12.1L/day/1000ppl mid-week and 19.4L/day/1000ppl on the weekend (Table 5, Figure 5).

The average consumption of cocaine for the R1-A catchment site was 81.1/day/1000ppl during the week and this increased to 132.5mg/day/1000ppl on the weekend (Table 5, Figure 1). For methamphetamine the estimated consumption was 1165.1mg/day/1000ppl mid-week and then 1175.4mg/day/1000ppl on the weekend (Table 5, Figure 2). For MDMA the average consumption was 167.9mg/day/1000ppl mid-week and this increased on the weekend to 253.8mg/day/1000ppl (Table 5, Figure 3). The average consumption of cigarettes during the week and on the weekend was 1522.5 and 1434.5 respectively (Table 5, Figure 4). The estimated consumption of alcohol from the R1-A treatment plant was 13.2L/day/1000ppl during the week and on the weekend this increased to 20.8L/day/1000ppl (Table 5, Figure 5).

In the R1-B catchment area, during the week, there was a mean consumption of 19.8, 869.4 and 20.8mg/day/1000ppl of cocaine, methamphetamine and MDMA respectively (Table 5, Figure 1, Figure 2, Figure 3). On the weekend, this increased to 64, 1040.6 and 105mg/day/1000ppl respectively (Table 5, Figure 1, Figure 2, Figure 3). On average, there were 1939.6 cigarettes consumed per day/1000ppl during the week decreasing to 1877.2 cigarettes/day/1000ppl on the weekend (Table 5, Figure 4). During the week alcohol consumption was estimated at 13.7L/day/1000ppl and this almost doubled on the weekend to 25.7L/day/1000ppl (Table 5, Figure 5).

For the R1-C Water treatment site there was an average consumption during the week of 14, 1500 and 32mg/day/1000ppl of cocaine, methamphetamine and MDMA respectively (Table 5, Figure 1, Figure 2, Figure 3). On the weekend the consumption of cocaine, methamphetamine and MDMA increased to 42, 1724 and 63mg/day/1000ppl, respectively (Table 5, Figure 1, Figure 2, Figure 3). The average number of cigarettes consumed increased slightly from 1378/day/1000ppl mid-week to 1445/day/1000ppl on the weekend (Table 5, Figure 4). The mean consumption of alcohol from the R1-C Water catchment area was 6.2L/day/1000ppl during the week and this increased to 10.9L/day/1000ppl on the weekend. (Table 5, Figure 5).

R1 – comparison between June 2015 and August 2016

Wastewater testing in R1 for the week 24th–30th June 2015 formed part of the second round of testing. Overall in R1, the average consumption of cocaine, methamphetamine and MDMA was 26, 786.5 and 210.9mg/day/1000ppl respectively (Figure 1, Figure 2, Figure 3, Appendix 2). The estimated mean alcohol and tobacco consumption for the whole week were 13.6L/day/1000ppl and 2101.1 cigarettes/day/1000ppl, respectively (Figure 4, Figure 5, Appendix 2).

Between June 2015 and August 2016, the average mid-week consumption of cocaine increased eightfold, methamphetamine increased 61% and MDMA decreased by 14% (Table 5, Appendix 2). During this period, the average mid-week consumption of alcohol remained stable but tobacco consumption decreased by 26% (Table 5, Appendix 2).

Between June 2015 and August 2016, the average weekend consumption increased for both cocaine and methamphetamine, but decreased by 35% for MDMA (Figure 1, Figure 2, Figure 3, Appendix 2). During this period, the average number of cigarettes consumed on the weekend per 1000 people decreased by 35%, but alcohol consumption per day per 1000 people remained stable (Figure 4, Figure 5, Appendix 2).

Regional Site 2 – August 2016

Table 6 and Figures 1 to 5 show the estimated mean alcohol, tobacco and illicit drug consumption from the R2 treatment plant for the week 5-11 August 2016. Overall in R2, the average consumption for cocaine, Methamphetamine and MDMA (ecstasy) for the week was 31.9, 956.4 and 243.8mg/day/1000pl, respectively (Table 6, Figure 1, Figure 2, Figure 3). The average consumption of alcohol in August 2016 in R2 was 12.6L/day/1000ppl and the average number of cigarettes/day/1000ppl was 1574.3 (Table 6, Figure 4, Figure 5).

There was an average mid-week consumption of 29.7, 926.3 and 137.2mg/day/1000ppl of cocaine, methamphetamine and MDMA respectively (Table 6). On the weekend the average consumption for all the drugs increased; cocaine was 37.5, methamphetamine increased to 1031.7mg/day/1000ppl and MDMA increased to 510.4mg/day/1000ppl (Table 6).

In R2 the consumption of cigarettes remained stable over the week whereas alcohol consumption increased from 10.5L/day/1000pl during the week to 17.7L/day/1000ppl on the weekend (Table 6).

R2 – comparison between July/August 2015 and May 2016

Wastewater testing in R2 for the week 29th July-4th August 2015 formed part of the second round of testing. Overall in R2, the average consumption of cocaine, methamphetamine and MDMA was 16, 821.6 and 420.9mg/day/1000ppl respectively (Figure 1, Figure 2, Figure 3, Appendix 3). The estimated mean alcohol and tobacco consumption for the whole week were 15.5L/day/1000ppl and 2389.1 cigarettes/day/1000ppl, respectively (Figure 4, Figure 5, and Appendix 3).

Between July/August 2015 and May 2016, the average consumption of cocaine remained stable, whereas that of methamphetamine and MDMA increased by 93% and 50%, respectively (Figure 1, Figure 2, Figure 3, Appendix 3). During this period, the average consumption of alcohol increased by 52%, but tobacco consumption remained stable (Figure 4, Figure 5, Appendix 3).

R2 – comparison between July/August 2015 and August 2016

In R2, between July/August 2015 and August 2016 the average consumption of cocaine doubled, and methamphetamine and MDMA consumption increased 16% and decreased 42%, respectively (Figure 1, Figure 2, Figure 3, Appendix 3). During this period the estimated mean alcohol and tobacco consumption for the whole week decreased 19% and 34%, respectively (Figure 4, Figure 5, and Appendix 3).

Regional Site 3 –August 2016

Table 6 and Figures 1 to 5 show the estimated mean alcohol, tobacco and illicit drug consumption from the R3 treatment plant for the week 8–13 August 2016. Overall in R3, the average consumption for cocaine, methamphetamine and MDMA (ecstasy) for the week was 59.5, 2473.1 and 126.2mg/day/1000ppl, respectively (Table 6, Figure 1, Figure 2, Figure 3). The average consumption of alcohol in August 2016 in R3 was 18L/day/1000ppl and the average number of cigarettes/day/1000ppl was 2554.9 (Table 6, Figure 4, and Figure 5).

There was an average mid-week consumption of 56.9, 2460 and 129.9mg/day/1000ppl of cocaine, methamphetamine and MDMA respectively (Table 6). On the weekend the average consumption for cocaine and methamphetamine increased to 72.5mg and 2538.7 mg, respectively, but MDMA consumption dropped to 107.6mg/day/1000ppl (Table 6).

In R3 the consumption of cigarettes increased from 2546/day/1000ppl during the week to 2599.7/day/1000ppl on the weekend, and alcohol consumption increased from 16.3L/day/1000ppl during the week to 26.5L/day/1000ppl on the weekend (Table 6).

R3 – comparison between June 2015 and June 2016

Wastewater testing in R3 in June 2015 formed part of the second round of testing. Overall in R3, the average consumption of cocaine, methamphetamine, and MDMA was 30, 3764.7, 317.9mg/day/1000ppl respectively (Figure 1, Figure 2, Figure 3, and Appendix 3). The estimated mean alcohol and tobacco consumption for the whole week were 41.2L/day/1000ppl and 6359.7 cigarettes/day/1000ppl, respectively (Figure 1, Figure 2, Figure 3, and Appendix 3).

Between June 2015 and June 2016, the average mid-week consumption of cocaine, methamphetamine and MDMA increased 20%, remained stable and increased 86%, respectively (Appendix 3). During this period, the average mid-week consumption of alcohol and tobacco decreased by 30% and 59%, respectively (Appendix 3).

When average weekend consumption was compared between June 2015 and June 2016, it appeared that cocaine consumption increased 39%, but methamphetamine and MDMA decreased 35% and 75%, respectively (Appendix 3). During this period, the average weekend consumption of alcohol and tobacco decreased by 64% and 73%, respectively (Appendix 3).

R3 – comparison between June 2015 and August 2016

Between June 2015 and August 2016, the average mid-week consumption of cocaine almost doubled, whereas methamphetamine and MDMA decreased by 23% and 18%, respectively (Appendix 3). During this period, the average mid-week consumption of alcohol and tobacco decreased by 47% and 55%, respectively.

Between June 2015 and August 2016, the average weekend consumption of cocaine increased 142%, but during this period methamphetamine and MDMA consumption decreased by 51% and 85%, respectively (Appendix 3). During this period, the average weekend consumption of alcohol and tobacco decreased by 61% and 68%, respectively (Appendix 3).

TABLE 4: ESTIMATED MEAN ALCOHOL, TOBACCO AND ILLICIT DRUG CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN MELBOURNE, AUGUST 2016

	Melbourne-Site 1		Melbourne-Site 2		Metropolitan Melbourne Total		
	Mid-week mean*	Weekend mean [#]	Mid-week mean*	Weekend mean [#]	Mid-week mean*	Weekend mean [#]	Total Week mean [§]
Cocaine (mg/day/1000ppl)	279.9	362.6	83.9	207.3	195.9	296.0	224.5
Methamphetamine (mg/day/1000ppl)	1143.7	1020.7	857.5	843.4	1021.0	944.7	999.2
MDMA (ecstasy) (mg/day/1000ppl)	267.6	336.0	219.8	221.1	247.1	286.8	258.4
Tobacco (cigarettes) (No/day/1000ppl)	1593.6	1380.5	1285.7	1178.3	1461.7	1293.8	1413.7
EtOH (alcohol) (L/day/1000ppl)	14.9	14.1	8.7	11.4	12.2	12.9	12.4

*Mid-week mean is an average of consumption from Monday to Friday

[#]Weekend mean is an average of consumption from Saturday and Sunday

[§]Total week mean is an average consumption from Monday to Sunday

TABLE 5: ESTIMATED MEAN ALCOHOL, TOBACCO AND ILLICIT DRUG CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN R1, AUGUST 2016

	Treatment Plant-R1A		Treatment Plant-R1B		Treatment Plant-R1C		R1 Total		
	Mid-week mean [*]	Weekend mean [#]	Mid-week mean [*]	Weekend mean [#]	Mid-week mean [*]	Weekend mean [#]	Mid-week mean [*]	Weekend mean [#]	Total Week mean [§]
Cocaine (mg/day/1000ppl)	81.1	132.5	19.8	64.0	14.0	42.0	67.4	114.7	80.9
Methamphetamine (mg/day/1000ppl)	1165.1	1175.4	869.4	1040.6	1500.0	1724.0	1205.1	1257.3	1220.0
MDMA (ecstasy) (mg/day/1000ppl)	167.9	253.8	20.8	105.0	32.0	63.0	139.2	216.2	161.2
Tobacco (# cigarette/day/1000ppl)	1522.5	1434.5	1939.6	1877.2	1378.0	1445.0	1518.8	1456.8	1501.1
EtOH (L/day/1000ppl)	13.2	20.8	13.7	25.7	6.2	10.9	12.1	19.4	14.2

^{*}Mid-week mean is an average of consumption from Monday to Friday

[#]Weekend mean is an average of consumption from Saturday and Sunday

[§]Total week mean is an average consumption from Monday to Sunday

TABLE 6: ESTIMATED MEAN ALCOHOL, TOBACCO AND ILLICIT DRUG CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN R2 AND R3, AUGUST 2016

	R2 Treatment Plant			R3 Treatment Plant		
	Mid-week mean*	Weekend mean [#]	Total week	Mid-week mean*	Weekend mean [#]	Total week
Cocaine (mg/day/1000ppl)	29.7	37.5	31.9	56.9	72.5	59.5
Methamphetamine (mg/day/1000ppl)	926.3	1031.7	956.4	2460.0	2538.7	2473.1
MDMA (ecstasy) (mg/day/1000ppl)	137.2	510.4	243.8	129.9	107.6	126.2
Tobacco (cigarettes/day/1000ppl)	1576.0	1570.0	1574.3	2546.0	2599.7	2554.9
EtOH (alcohol) (L/day/1000ppl)	10.5	17.7	12.6	16.3	26.5	18.0

*Mid-week mean is an average of consumption from Monday to Friday

[#] Weekend mean is an average of consumption from Saturday and Sunday

\$Total week mean is an average consumption from Monday to Sunday

FIGURE 1: ESTIMATED MEAN COCAINE CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN MELBOURNE AND REGIONAL VICTORIA, MAR 2014, MAR/JUN/JUL 2015, MAY 2016, AUG 2016

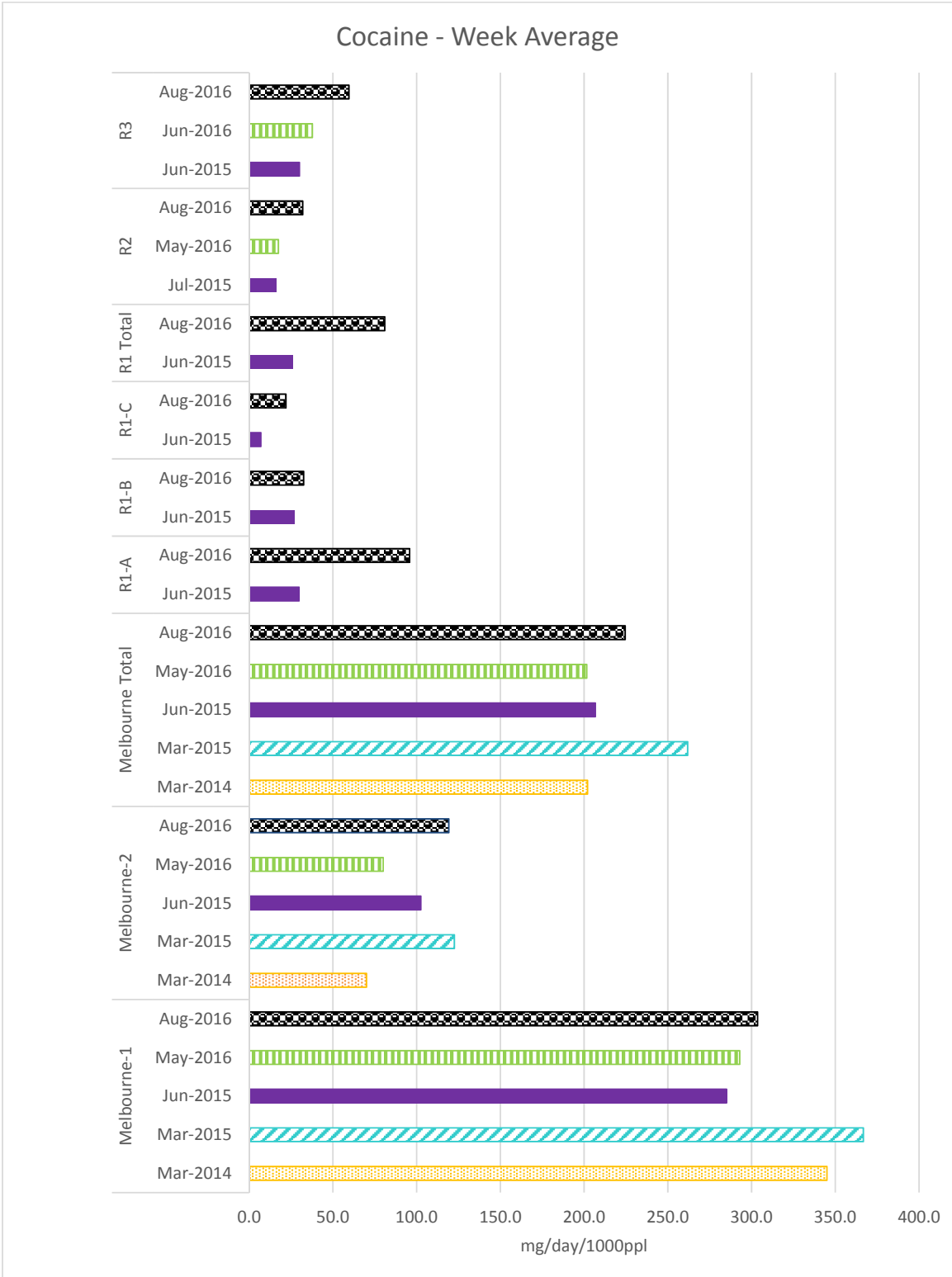


FIGURE 2: ESTIMATED MEAN METHAMPHETAMINE CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN MELBOURNE AND REGIONAL VICTORIA, MAR 2014, MAR/JUN/JUL 2015, MAY 2016, AUG 2016

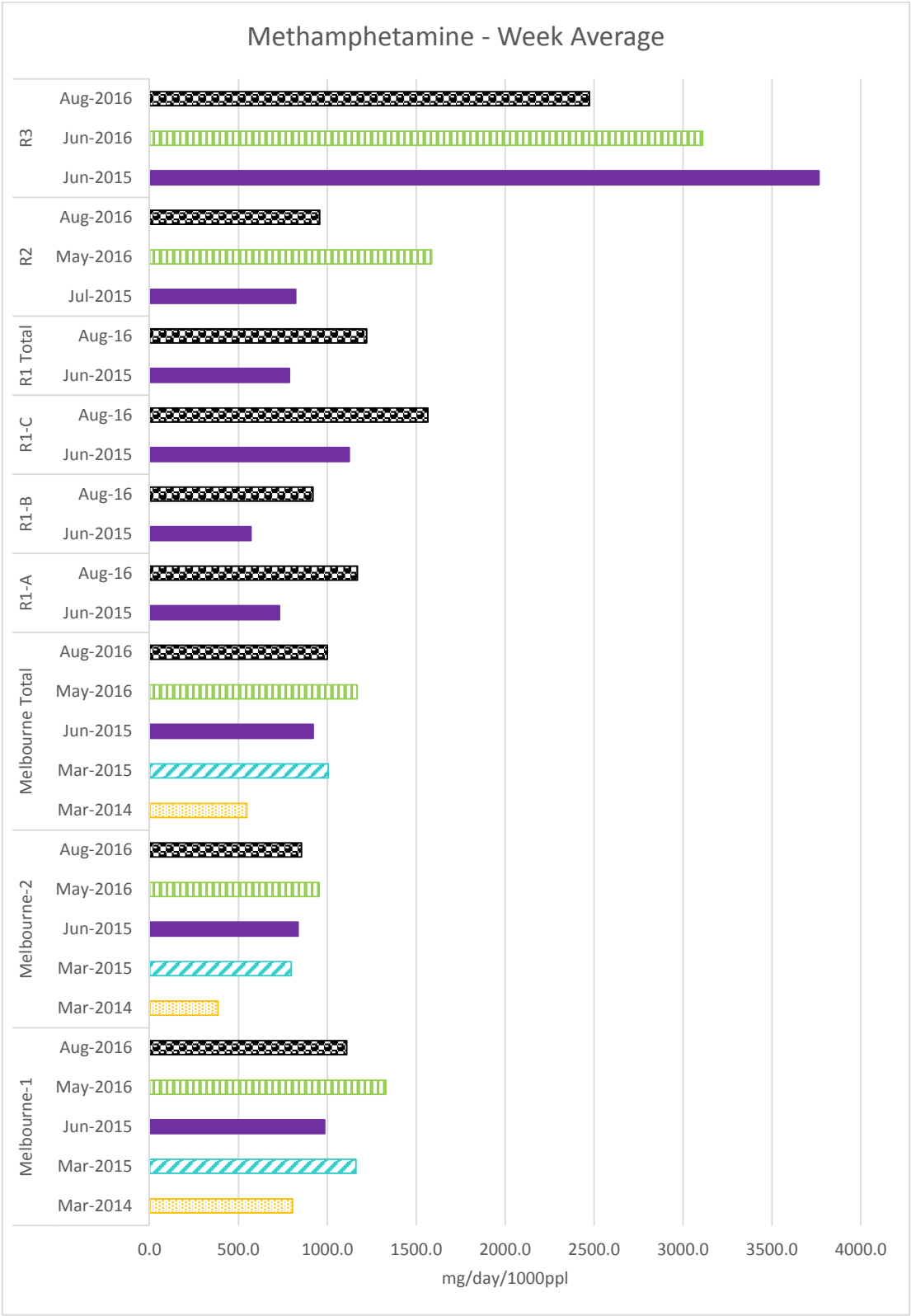


FIGURE 3: ESTIMATED MEAN MDMA (ECSTASY) CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN MELBOURNE AND REGIONAL VICTORIA, MAR 2014, MAR/JUN/JUL 2015, MAY 2016, AUG 2016

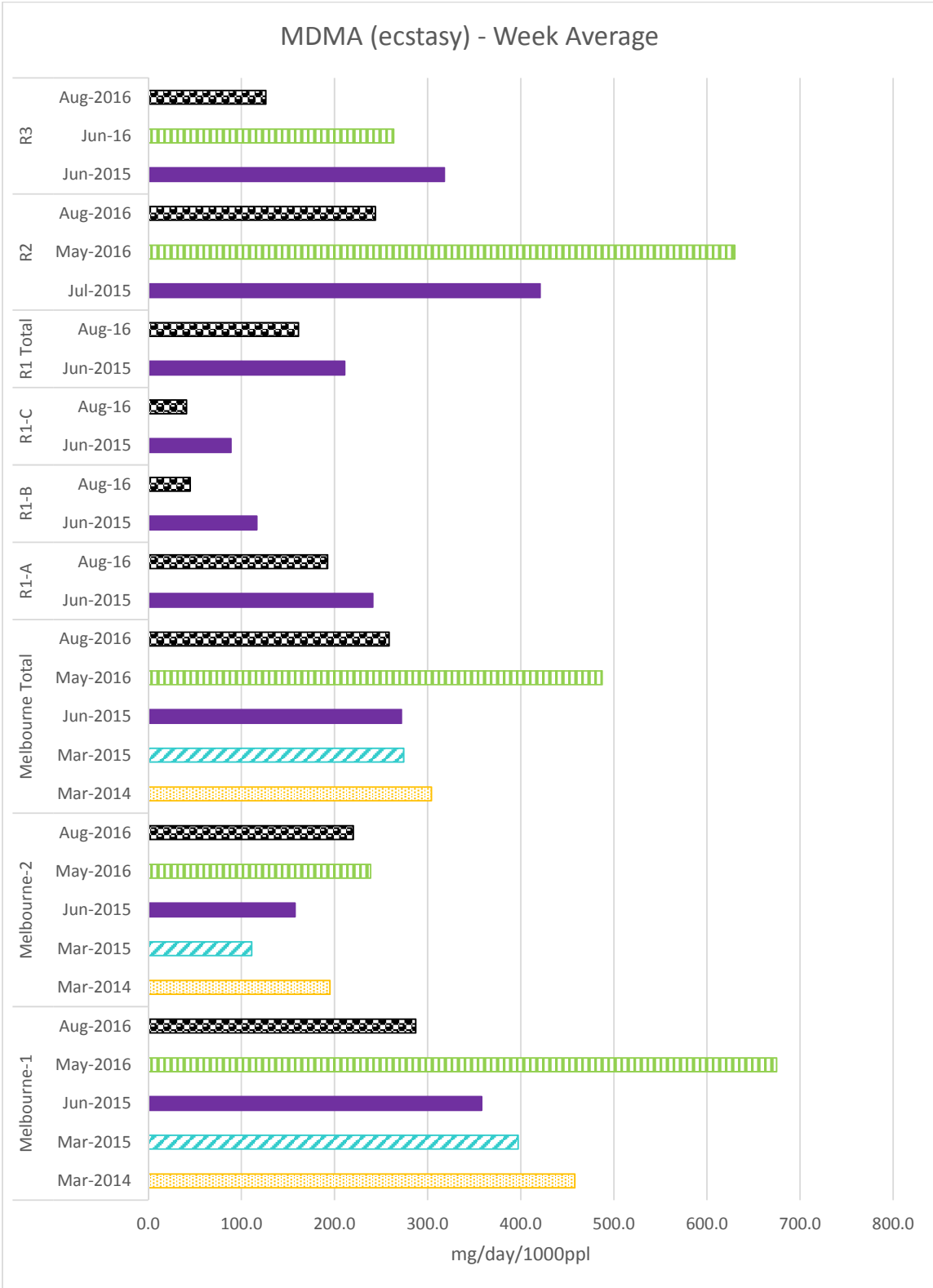


FIGURE 4: ESTIMATED MEAN CIGARETTE CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN MELBOURNE AND REGIONAL VICTORIA, MAR 2014, MAR/JUN/JUL 2015, MAY 2016, AUG 2016

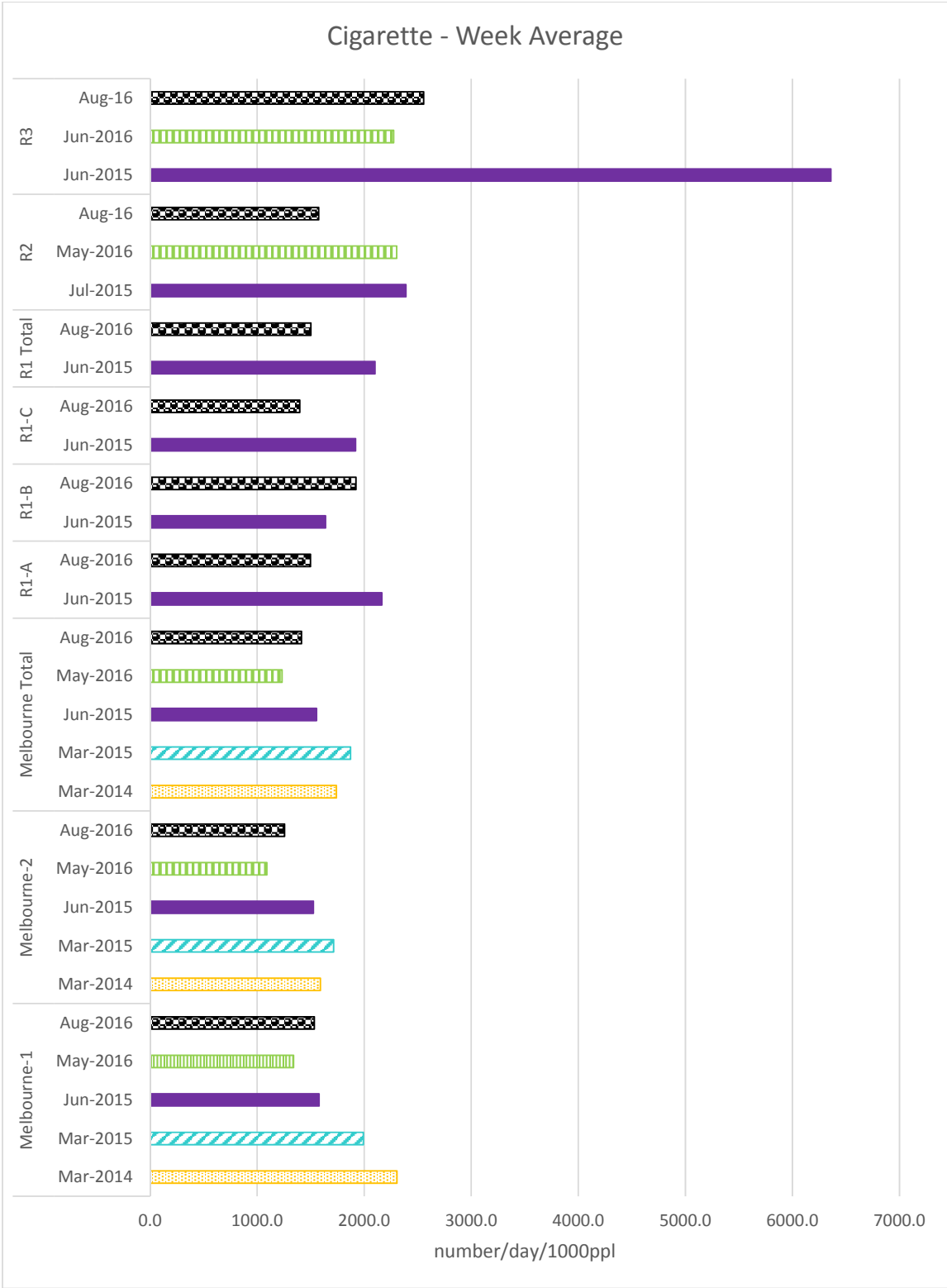
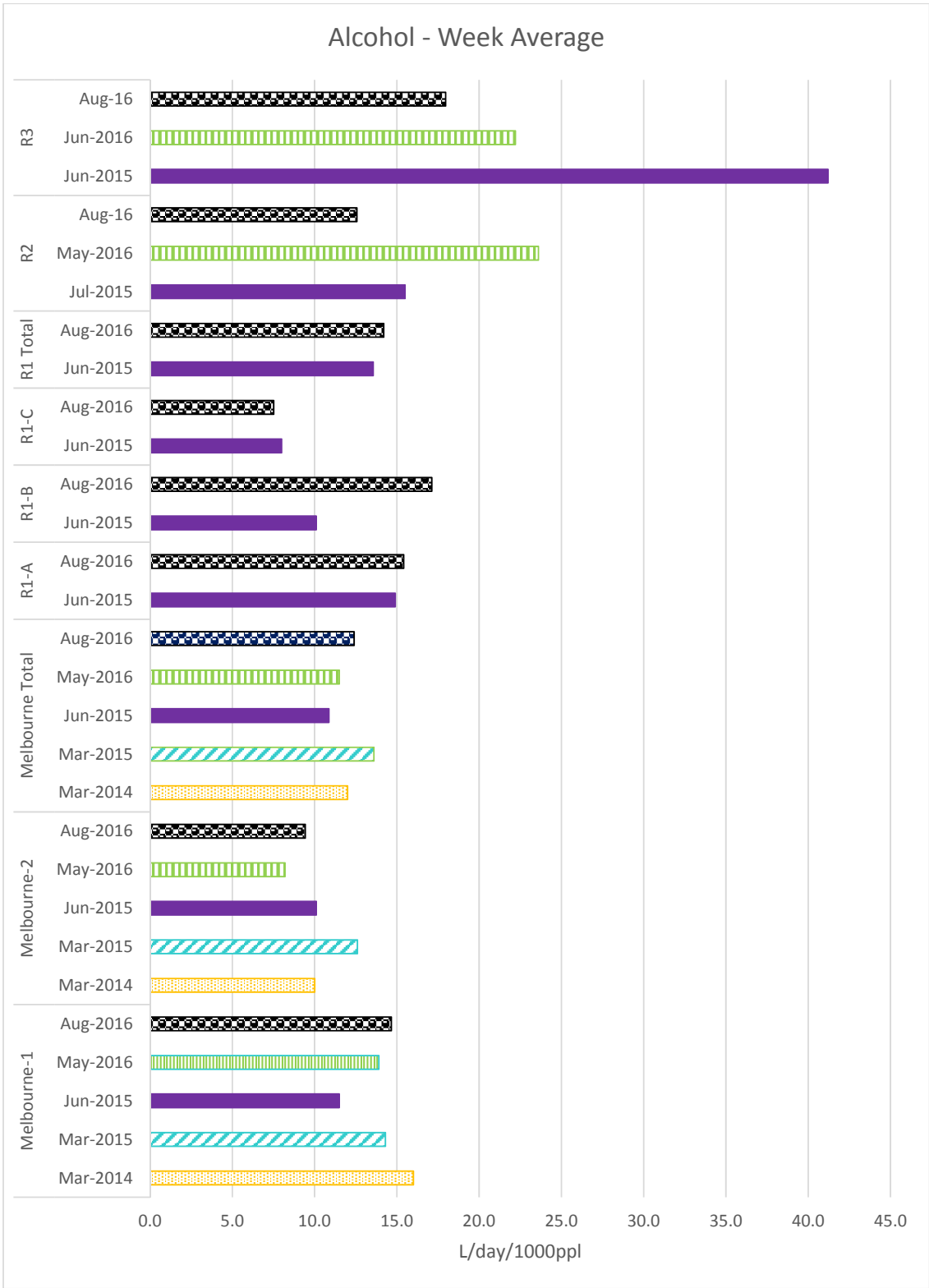


FIGURE 5: ESTIMATED MEAN ALCOHOL CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN MELBOURNE AND REGIONAL VICTORIA, MAR 2014, MAR/JUN/JUL 2015, MAY 2016, AUG 2016



Summary

This study covered areas in metropolitan Melbourne and several sites in regional Victoria. Selected drugs were analysed from samples collected during one week in August 2016 in each treatment plant. This study showed interesting findings for several drugs of concern at the population level.

In metropolitan Melbourne for the week 5-11 August 2016, the average consumption of cocaine, MDMA and methamphetamine was 224.5, 258.4 and 999.2mg/day/1000ppl, respectively. Results from August 2016 in metropolitan Melbourne were compared with May 2016, and showed an 11% increase in cocaine consumption, a 14% decrease in methamphetamine consumption and a 47% decrease in MDMA consumption. Alcohol and tobacco consumption remained stable and increased 15%, respectively, between May 2016 and August 2016.

When the results from May 2016 were compared with June 2015, the consumption of MDMA and methamphetamine consumption increased 79% and 27%, respectively, but cocaine consumption decreased marginally. Alcohol consumption remained almost the same and tobacco consumption decreased 21% in metropolitan Melbourne between June 2015 and May 2016.

In August 2016, Melbourne-Site 1 catchments had higher mean consumption levels for all substances tested, both during the week and on the weekend, compared with Melbourne-Site 2 catchments. This was consistent when compared to either May 2016 or June 2015 results.

In R2 for the week 5-11 August 2016, the average consumption of cocaine was 31.9mg/day/1000ppl which is very low compared to Melbourne. Average consumption of MDMA was 243.8mg/day/1000ppl, almost similar to the Melbourne consumption. Methamphetamine consumption was almost four times that of MDMA at 956.4mg/day/1000ppl, and 4% lower than Melbourne consumption levels.

To observe the annual consumption trend in R2, results from August 2016 were compared with July 2015, and showed a twofold increase in cocaine consumption from 16 mg to 32mg/day/1000ppl. Methamphetamine consumption increased 16% in the 12 months and MDMA consumption decreased 42%. During this period alcohol and tobacco consumption decreased 19% and 34%, respectively.

During 8-13 August 2016 in R3, the average consumption of cocaine was about 60mg/day/1000ppl, which is almost 74% lower compared to Melbourne. Consumption of MDMA was an average of 126.2mg/day/1000ppl, approximately 74% lower than Melbourne, and 50% lower than R2. Methamphetamine consumption was 20 times MDMA consumption at 2473.13mg/day/1000ppl, approximately 148% higher than Melbourne and 2.5 times R2 consumption levels.

When the results from June 2016 were compared with June 2015, the consumption of cocaine increased 27%, and both methamphetamine and MDMA decreased 17%. During this period the consumption of alcohol and tobacco decreased 46% and 64%, respectively.

In R1 for the week 5-11 August 2016, the average consumption of cocaine, MDMA and methamphetamine was 80.9, 161.2 and 1220mg/day/1000ppl, respectively. Results from August 2016 in R1 were compared with June 2015, and showed a threefold increase in cocaine consumption, a 55% increase in methamphetamine consumption and a 24% decrease in MDMA consumption.

Context

To give context to the wastewater results presented, ambulance attendances were analysed for August 2016 and June 2015. From June 2015 to August 2016, alcohol-related ambulance attendances in metropolitan Melbourne decreased 6%, decreased 3% in R1, increased 60% in R2 and decreased 17% in R3. Our waste water analysis indicates little or no change in alcohol consumption for Metropolitan Melbourne and R1 during this period, but a 19% decrease in R2 and a 56% decrease in R3.

For amphetamine and ecstasy involvement in metropolitan Melbourne, attendances increased from June 2015 to August 2016 by 45% and 51%, respectively. However, wastewater analysis showed no significant change in methamphetamine consumption, and 79% increase in ecstasy consumption levels in wastewater in metropolitan Melbourne, over the 14 months. During the same period, ambulance attendances involving cocaine remained the same for metropolitan Melbourne, which is in harmony with our wastewater analysis.

In August 2016, for ambulance attendances related to amphetamine, ecstasy and cocaine use, there were significantly smaller numbers (i.e. <5) in regional sites compared to metropolitan Melbourne with the only exception of 15 amphetamine-related attendances in R1. Whilst this is fairly consistent with lower mean consumption levels of cocaine and MDMA, tested through wastewater in R1, R2 and R3, this is not consistent with the high consumption levels of methamphetamine determined through wastewater analysis in R3. This implies that whilst consumption of methamphetamine may be higher in R3 compared to Melbourne, this is not leading to harms requiring an ambulance.

Although the time period of data collection does not coincide with this report, here we add one of the key findings from the 2016 National Drug Strategy Household Survey [10], in order to give an overall picture of the consumption pattern:

- Significant declines were seen in the recent use of meth/amphetamines (from 2.1% to 1.4% from 2013 to 2016).
- Cocaine is now the second most commonly used illegal drug in the last 12 months after cannabis.
- Crystal (or ice) meth/amphetamines continued to be the preferred form of meth/amphetamines used in 2016. About 62% recent users had used crystal/ice in the previous 12 months and for 57% of recent users this was the main form of meth/amphetamines used in the previous 12 months. Powder as the main form of meth/amphetamines used continued to decline (significant decrease from 29% in 2013 to 20% in 2016).

Finally, wastewater analysis is population based and cannot provide person level information regarding individuals' drug consumption, frequency of use or poly-drug use. However, wastewater analysis can efficiently provide reliable objective chemical data on the use of drugs of major concern to the community such as alcohol, methamphetamine, cocaine and MDMA [2]. This information provides tangible consumption level data, previously only obtained through survey data.

Limitations

It should be noted that there prevail some uncertainties in wastewater analysis. Most drugs are metabolised in the body and many are cleared through the kidneys in water soluble form. Either the unchanged drug or its metabolite may be excreted and enter the sewer system. There it contributes to the total effluent which reaches a treatment plant. Therefore, the amount of drug can be measured as a concentration expressed as mass of drug per volume of wastewater entering the treatment plant. When the daily flow rate is known, i.e. the total amount of water flowing into the plant on any given day, the absolute amount of drug excreted per day can be derived. Combining the measured amount with the clearance rate and population served by a treatment plant, the daily mass load per plant can be calculated and expressed per number of inhabitants (or more usually, per thousand inhabitants). When a typical dose can be defined, the figure can be reported as doses per day per thousand people according to the calculation provided in the Methods section (Equation 1, page 11).

A number of factors may influence the accuracy of the result obtained from Equation 1. In terms of errors, site specific variables range from inherent errors/bias within the treatment plant flow meters, autosamplers or storage, to analytical variability and uncertainties in population estimates.

One of the largest uncertainties involves the population estimate of the area being served by the treatment plant. Plants have a maximum design capacity, so the proportional maximum flow can be used to gauge the contributing population. More commonly, population is based on census data for the surrounding community. The Australian Bureau of Statistics (ABS) suggests on an annual basis the growth in population in specific areas. Therefore, based on census figures, the population in a post code area can be determined to some degree of accuracy. However, uncertainty still exists regarding the number of people residing in a post code area over a 24 hour interval, considering work, travelling, etc. Another method is based on the number of waste connection points in a particular catchment. Each connection point is assigned a number of people and the overall population is derived by multiplying the connection points by the population factor.

Depending on the residence time of an excreted drug metabolite in the sewer system, some decomposition may occur in the aerobic environment. The same applies between sample collection and analysis. This would include storage in a 24-hour autosampler at the treatment plant, transportation time, refrigeration and presence of a preservative. Nevertheless, most of the drugs included in this report have been shown to be relatively stable within the sewer network and under appropriate storage conditions [11, 12].

Most Australian capital city sites employ separate household and industrial sewer systems from stormwater. However, some in-and exfiltration due to porosity, damage to pipes, corrosion, tidal flow, etc. cannot be avoided and may affect the levels of drug measured entering the treatment plant.

Excretion rate of the drug is also a potential confounding factor. Some individuals metabolise a drug faster than others, and so the clearance rate, or even the proportion of drug excreted may vary significantly. Co-ingestion of alcohol or other drugs may similarly affect the metabolism of a drug. However, on a population scale, it is not unreasonable to expect that differences may average out and the mean remain relatively constant.

Errors/variation within the extraction and analysis methods is usually less than 10%, but in rare instances, background interference may cause signal strength. This is corrected for using internal standards, which are deuterated analogues of the target compounds. Some groups suggest the

error/variation of the final estimate, including all possible sources of error, can be of the order of 20-30%. A conservative estimate for the uncertainty of each measurement might be $\pm 25\%$.

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Appendix 1

APPENDIX 1: ESTIMATED MEAN ALCOHOL, TOBACCO AND ILLICIT DRUG CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN MELBOURNE, MARCH 2015, JUNE 2015 AND MAY 2016

	Melbourne Site 1 Total Week Mean ^{\$}			Melbourne Site 2 Total Week Mean ^{\$}			Metropolitan Melbourne Total Week Mean ^{\$}		
	March 2015	June 2015	May 2016	March 2015	June 2015	May 2016	March 2015	June 2015	May 2016
Cocaine (mg/day/1000ppl)	366.7	285.1	292.9	123.0	102.5	80.2	261.8	206.7	201.5
Methamphetamine (mg/day/1000ppl)	1160.3	984.6	1327.7	796.0	834.8	953.3	1004.0	920.3	1166.9
MDMA (ecstasy) (mg/day/1000ppl)	397.1	358.0	674.7	111.0	157.6	238.7	274.3	271.9	257.8
Tobacco (# cigarette/day /1000ppl)	1991.4	1577.9	1338.8	1713.0	1525.3	1089.4	1871.9	1555.3	1231.7
EtOH (alcohol) (L/day/1000ppl)	14.3	11.5	13.9	13.0	10.1	8.2	13.6	10.9	11.5

^{\$}Total week mean is an average consumption from Monday to Sunday

Appendix 2

APPENDIX 2: ESTIMATED MEAN ALCOHOL, TOBACCO AND ILLICIT DRUG CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN R1, JUNE 2015

	Treatment Plant R1-A		Treatment Plant R1-B		Treatment Plant R1-C		R1 Total		
	Mid-week mean [*]	Weekend mean [#]	Mid-week mean [*]	Weekend mean [#]	Mid-week mean [*]	Weekend mean [#]	Mid-week mean [*]	Weekend mean [#]	Total Week mean [§]
Cocaine (mg/day/1000ppl)	7.0	86.9	7.0	76.6	7.0	7.0	7.0	73.6	26.0
Methamphetamine (mg/day/1000ppl)	688.2	838.4	518.0	700.4	1107.4	1161.4	747.6	883.8	786.5
MDMA (ecstasy) (mg/day/1000ppl)	188.3	373.7	53.5	274.1	63.8	151.2	162.0	333.3	210.9
Tobacco (# cigarette/day/1000ppl)	2106.3	2313.6	1515.3	1946.6	1877.5	2020.6	2041.8	2249.3	2101.1
EtOH (L/day/1000ppl)	12.6	20.7	7.1	17.8	6.8	11.1	11.4	19.0	13.6

^{*}Mid-week mean is an average of consumption from Monday to Friday

[#] Weekend mean is an average of consumption from Saturday and Sunday

[§]Total week mean is an average consumption from Monday to Sunday

Appendix 3

APPENDIX 3: ESTIMATED MEAN ALCOHOL, TOBACCO AND ILLICIT DRUG CONSUMPTION USING WASTEWATER ANALYSIS AT TREATMENT PLANTS IN R2 (JULY/AUGUST 2015, MAY 2016) AND R3 (JUNE 2015, MAY/JUNE 2016)

	R2 Treatment Plant						R3 Treatment Plant					
	Jul/Aug 2015			May 2016			Jun 2015			May/Jun 2016		
	Mid-week mean*	Weekend mean [#]	Total week mean ^{\$}	Mid-week mean*	Weekend mean [#]	Total week mean ^{\$}	Mid-week mean*	Weekend mean [#]	Total week mean ^{\$}	Mid-week mean*	Weekend mean [#]	Total week mean ^{\$}
Cocaine (mg/day/1000ppl)	7.0	38.4	16.0	17.6	17	17.4	30.0	30.0	30.0	36.1	41.8	37.7
Methamphetamine (mg/day/1000ppl)	794.7	889.0	821.6	1570.4	1622.4	1585.3	3196.7	5184.6	3764.7	3010.5	3358.2	3109.8
MDMA (ecstasy) (mg/day/1000ppl)	320.3	672.4	420.9	752.5	323.1	629.8	159.3	714.6	317.9	296.5	181.0	263.5
Tobacco(#cigarette/day/1000ppl)	2345.9	2497.1	2389.1	2331.0	2233.0	2303.0	5669.4	8085.4	6359.7	2300.6	2206.5	2273.7
EtOH (L/day/1000ppl)	12.4	23.2	15.5	27.3	14.3	23.6	30.7	67.4	41.2	21.5	24.1	22.2

*Mid-week mean is an average of consumption from Monday to Friday

[#] Weekend mean is an average of consumption from Saturday and Sunday

^{\$}Total week mean is an average consumption from Monday to Sunday