RELATIVE BIOAVAILABILITY OF ARSENIC IN SOILS FROM BUTTE, MONTANA

Stan W. Casteel, DVM, PhD, DABVT
Principal Investigator
Tim Evans, DVM
Steve Morris, M.S.
Co-Investigators
Veterinary Medical Diagnostic Laboratory
College of Veterinary Medicine
University of Missouri, Columbia
Columbia, Missouri

Susan Griffin, PhD, DABT
Study Design and Technical Advisor
US Environmental Protection Agency – Region 8
Denver, Colorado

William J. Brattin, PhD
Angela M. Wahlquist, MS
Technical Consultants
Syracuse Research Corporation
Denver, Colorado

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EXECUTIVE SUMMARY

The gastrointestinal absorption of arsenic from soil samples collected from residential properties at the Butte Arsenic Superfund site was measured using young swine. Test materials include composite soil with arsenic concentrations of 234 ppm (TM1) and 367 ppm (TM2). Groups of animals (four animals per dose group) were given oral doses of reference material (sodium arsenate) or test material twice a day for 12 days. Urine excreted by each animal was collected on days 6-7, 8-9 and 10-11. The urinary excretion fraction (UEF) (the ratio of the amount excreted per 48 hours divided by the dose given per 48 hours) was calculated for each test material using linear regression analysis. The relative bioavailability (RBA) of arsenic in test material compared to that in sodium arsenate (abbreviated NaAs) was calculated as:

$$RBA = \frac{UEF(test\ material)}{UEF(NaAs)}$$

The results are summarized below:

Test Material	RBA (90% CI)
TM1	17% (14-22%)
TM2	22% (17-29%)

CI = Confidence Interval

Using sodium arsenate as a relative frame of reference, the RBA estimate for TM1 is 17% and 22% for TM2. These RBA estimates are significantly lower than the default value of 80%-100% that is usually employed for arsenic in soil when reliable site-specific data are lacking. This indicates that the arsenic in these soil samples is not as well absorbed as soluble arsenic. Use of these data is likely to improve the accuracy of risk estimates for humans who may incidentally ingest these soils.

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1.0 INTRODUCTION

Accurate assessment of the health risks resulting from oral exposure to arsenic requires knowledge of the amount of arsenic absorbed from the gastrointestinal tract into the body. This information on absorption may be described either in absolute or relative terms:

Absolute Bioavailability (ABA) is the ratio of the amount of arsenic absorbed to the amount of arsenic ingested:

$$ABA = \frac{Absorbed\ Dose}{Ingested\ Dose}$$

This ratio is also referred to as the oral absorption fraction (AF_o).

Relative Bioavailability (RBA) is the ratio of the absolute bioavailability of arsenic present in some test material to the absolute bioavailability of arsenic in some appropriate reference material:

$$RBA = \frac{ABA\ (test\ material)}{ABA\ (reference\ material)}$$

Usually the form of arsenic used as the reference material is an arsenic compound dissolved in water or some readily soluble form (e.g., sodium arsenate) that is expected to completely dissolve when ingested.

For example, if 100 µg of arsenic dissolved in drinking water were ingested and a total of 90 µg were absorbed into the body, the ABA would be 0.90 (90%). Likewise, if 100 µg of arsenic contained in soil were ingested and 30 µg were absorbed into the body, the ABA for soil would be 0.30 (30%). If the arsenic dissolved in water were used as the reference substance for describing the relative amount of arsenic absorbed from soil, the RBA would be 0.30/0.90, or 0.33 (33%).

Using Relative Bioavailability Data to Improve Risk Calculations for Arsenic

When reliable data are available on the relative bioavailability of arsenic in a site medium (e.g., soil), this information can be used to adjust the default toxicity values (RfD_{IRIS}, SF_{IRIS}) for arsenic to account for differences in absorption between arsenic ingested in water (RBA_w) and arsenic ingested in site media, as follows:

$$RfD_{adj} = \frac{RfD_{IRIS}}{RBA_w}$$

$$SF_{adj} = SF_{IRIS} \cdot RBA_w$$

Alternatively, it is also acceptable to adjust the dose (rather than the toxicity factors) as follows:

$$Dose_{adj} = Dose_{default} \cdot RBA_w$$

This dose adjustment is mathematically equivalent to adjusting the toxicity factors as described above.

Purpose of this Study

Investigations performed at the Butte Priority Soils Operable Unit in Butte, Montana, have revealed that some residential properties have yard soil that is contaminated with elevated levels of arsenic. This study was performed in order to obtain site-specific data on the relative bioavailability of arsenic in yard soils in order to help improve the accuracy of risk calculations for residents who may be exposed to arsenic in soil.

2.0 STUDY DESIGN

This investigation of arsenic relative bioavailability was performed according to the basic design presented in Table 2-1. As shown, the study investigated arsenic absorption from sodium arsenate (the reference material) and from two site-specific soils (the test materials), each administered to groups of animals at three different dose levels for 12 days (a detailed schedule is presented in Appendix A, Table A-1). Additionally, the study included a non-treated group to serve as a control for determining background arsenic levels. All doses were administered orally.

2.1 Test Materials

2.1.1 Test Material Description and Preparation

The test materials used in this investigation are two soil samples from Butte, Montana. Test Material 1 (USEPA sample number 8-37926) has been tested previously in the swine bioassay system (USEPA, 1996), and sufficient material existed to repeat the analysis using the same material. This soil sample is a composite collected from the Butte Priority Soils Operable Unit (BPSOU) of the Silver Bow Creek/ Butte Area NPL Site in Butte, Montana. The sampling investigation focused on four source areas: the Little Mina-1, Little Mina-2, West Ruby, and North Emma waste rock dumps. At each source area, five sub-samples were collected and composited, and these were then further composited across source areas to yield the sample used in the study.

Test Material 2 (USEPA sample number BPSOU-0501-ASBIO) was collected by CDM in May 2001 (CDM Federal, 2001). This soil sample is a composite collected from a residential property located adjacent to a railroad grade in Butte, Montana. A total of 5 soil samples from this property were combined in order to prepare the arsenic bioavailability composite sample.

Both composite samples were prepared for administration to the animals by air-drying (maximum temperature = 40°C) followed by sieving through a nylon mesh to yield particles less than about 250 μm. This was done because it is believed that fine particles are most likely to adhere to the hands and be ingested by hand-to-mouth contact, and are most likely to be available for absorption. Grinding was not employed.

2.1.2 Detailed Characterization of Test Materials

Arsenic Concentration

Aliquots of each test material were analyzed for arsenic by inductively coupled plasma (ICP) spectroscopy. The results from these analyses are presented below.

Test Material	Sample ID #	Arsenic Concentration (mg/kg)
1	8-37926 (previously tested)	234*
2	BPSOU-0501-ASBIO	367**

* Based on quadruplicate analyses via ICP

** Based on triplicate analyses via ICP

Concentration of Other Inorganics

Each sample was analyzed for EPA's Target Analyte List (TAL) of inorganic chemicals. Results are shown in Table 2-2.

Particle Speciation, Size, and Matrix Association

Each test material was characterized by electron microprobe analysis (EMPA) in order to identify the different mineral forms of arsenic that were present in each sample and to estimate how much of the total arsenic was present in each form. In addition, the size distribution of the particles was characterized along with the matrix association of each particle. The detailed data are presented in Appendix B and the results are summarized below.

Arsenic Phases

The following table lists the different arsenic phases observed in the two test materials and gives the relative mass of arsenic (RMA) for each phase in each test material. The RMA is the estimated percentage of the total arsenic in a sample that is present in a particular phase.

Arsenic Phase	Test Material	
	TM1	TM2
FeAs Sulfate	53%	18%
Clays	--	0%
FeAs Oxide	20%	39%
MnAs Oxide	16%	--
As Phosphate	8%	--
AgAsS	2%	--
Sulfosalts	--	42%
Pyrite	--	0.1%
AsMSO4	--	0.3%
Slag	--	0.0%
Barite	0.1%	--
Total Number of Particles Counted	636	137

As seen, arsenic is primarily associated with FeAs sulfate in TM1 and with sulfosalts and FeAs oxide in TM2. These differences in mineral phase may influence the RBA of the arsenic in the materials.

It is important to note that these quantitative estimates of relative arsenic mass are based on examination of a limited number of arsenic-bearing particles in each sample, particularly for Test

Material 2 (N = 137). Consequently, the quantitative values reported should not be considered to be highly precise, and apparent differences between samples may be partly due to random variation in the analysis rather than authentic differences in composition.

Particle Size Distribution

Particle size is a potentially important contributor to RBA because the fraction of a particle that undergoes dissolution in gastrointestinal fluids is likely related to the surface area to volume ratio (this ratio is larger for small particles than large particles). The distribution of particle sizes for arsenic-bearing grains in these test materials is summarized below:

Test Material	Percent of Particles by Size Class		
	0-25 µm	26-100 µm	>100 µm
TM1	49%	40%	11%
TM2	57%	39%	4%

As seen, approximately half of the particles in each test material are very small (25 µm or smaller) and the majority (89% to 96%) are 100 µm or less.

Matrix Association

Arsenic-containing particles may be characterized according to their association with other particles into four types, as follows:

Matrix Association	Description
Liberated	A grain of arsenic-containing material that is not attached to or contained within any other particle
Rimming	Arsenic is present on the outer surface of a particle, usually as a consequence of adsorption or precipitation
Cemented	The arsenic-containing particle is loosely bound to or associated with other particles or phases that do not contain arsenic
Included	The arsenic-containing particle is entirely contained within another particle

In the first three types of matrix association, the arsenic is exposed at the surface of some or all of the particle, and hence the arsenic is available to be dissolved by gastrointestinal fluids. Particles that are fully included in other particles are not exposed to external fluids and are not likely to have high bioavailability. The distribution of matrix associations for arsenic-bearing particles in the test materials from this site is summarized below:

Test Material	Percent of Particles by Matrix Class			
	Liberated	Rimming	Cemented	Included
TM1	46%	6%	40%	8%
TM2	61%	6%	33%	0%

As seen, relatively few particles are fully included, and 92-100% of the particles are entirely or partially exposed to external fluids. This suggests that the RBA of the arsenic is likely to be determined primarily by mineral phase and/or particle size rather than by matrix association.

In Vitro Bioaccessibility

The details of the method used to measure the *in vitro* bioaccessibility of arsenic are described in USEPA (1999). In brief, samples of soil are placed in a test fluid designed to be similar to gastric fluid and the fraction of the total amount of arsenic in the sample which dissolves into the fluid under a specified set of conditions (temperature, time, pH) is measured. This fraction of the total arsenic that is solubilized is referred to as the *in vitro* bioaccessibility (IVBA). The IVBA results for the two test materials in this study are summarized below:

Test Material	IVBA
TM1	9% *
TM2	13% **

* Based on five analyses
** Based on duplicate analyses

2.2 Experimental Animals

Juvenile swine were selected for use in this study because they are considered to be a good physiological model for gastrointestinal absorption in children (Weis and LaVelle, 1991). The animals were intact males of the Pig Improvement Corporation (PIC) genetically defined Line 26, and were purchased from Chinn Farms, Clarence, MO.

The animals were housed in individual stainless steel cages. All animals were held for several days prior to beginning exposure to test materials to allow them to adapt to their new environment and to ensure that all of the animals were healthy. In order to help minimize weight variations between animals and groups, three animals most different in body weight on day -4 (either heavier or lighter) were also excluded. The remaining animals were assigned to dose groups at random (group assignments are presented in Appendix A, Table A-2). When exposure began (day zero), the animals were about 5-6 weeks old and weighed an average of about 8.6 kg. Animals were weighed every three days during the course of the study. On average, animals gained about 0.3 to 0.4 kg/day, and the rate of weight gain was comparable in all groups. These body weight data are summarized in Figure 2-1 and are also presented in Appendix A, Table A-3.

2.3 Diet

Each day every animal was given an amount of standard swine chow (University Feed Mill S II (2) starter ration without added antibiotics) equal to 5% of the mean body weight of all animals on study. Feed was administered in two equal portions (2.5% of the mean body weight) at 11:00 AM and 5:00 PM daily. Drinking water was provided *ad libitum* via self-activated watering nozzles within each cage.

Based on data from previous arsenic studies, the estimated intake of arsenic in unexposed animals is less than 0.1 μg/kg-day via water and about 10 μg/kg-day via the diet.

2.4 Dosing

Animals were exposed to sodium arsenate (abbreviated in this report as "NaAs") or a test material (site soil) for 12 days, with the dose for each day being administered in two equal portions given at 9:00 AM and 3:00 PM (two hours before feeding). Dose material was placed in the center of a small portion (about 5 grams) of moistened feed (this is referred to as a "doughball"), and this was administered to the animals by hand.

The dose levels administered were based on the arsenic content of the test material, with target doses of 300, 600, and 900 μg/day for NaAs and each test material. The administered arsenic doses are presented in Appendix A, Table A-3, and the body-weight adjusted doses are presented in Appendix A, Table A-4. These actual administered doses were used for all RBA calculations.

2.5 Collection and Preparation of Samples

Urine

Samples of urine were collected from each animal for three consecutive 48-hour periods, on days 6/7, 8/9, and 10/11, with one exception. It was determined during the first few days of dosing that there were insufficient quantities of Test Material 1 available for dosing according to the protocol. In order to account for this shortage of test material, the dosing for groups 5, 6, and 7 was modified to end one day earlier than originally scheduled. As a result, urine collection for these animals was altered to consist of a 24-hour collection (rather than 48-hour) on day 10, with all other collections being conducted according to schedule.

Urine collections began at 9:00 AM and ended 48 hours later. The urine was collected in a stainless steel pan placed beneath each cage, which drained into a plastic storage bottle. Each collection pan was fitted with a nylon screen to minimize contamination with feces, spilled food, or other debris. Plastic diverters were used to minimize urine dilution with drinking water spilled by the animals from the watering nozzle into the collection pan, although this was not always effective in preventing dilution of the urine with water. Due to the length of the collection period, collection containers were emptied at least twice daily into a separate holding container. This ensured that there was no loss of sample due to overflow.

At the end of each collection period, the urine volume was measured (see Appendix A, A-5) and 60-mL portions were removed for analysis. A separate 250-mL aliquot was retained as an archive sample. Each sample was acidified by the addition of concentrated nitric acid. The samples were stored refrigerated until arsenic analysis.

Feces

Feces were collected by placing a fine-mesh nylon screen beneath each cage. Samples were transferred from the screen into a storage container twice per day, and the final sample (collected over 48 hours) was weighed (see Appendix A, Table A-6). As for urine, the feces collection for Groups 5, 6, and 7 was altered to consist of a 24-hour collection (rather than 48-hour) on day 10, with all other collections being conducted according to schedule. Aliquots of 20-25 grams of feces were weighed and freeze dried.

2.6 Arsenic Analysis

2.6.1 Urine

Urine samples were arranged in a random sequence and submitted to the laboratory for analysis in a blind fashion.

Details of urine sample preparation and analysis are provided in the study project plan (USEPA, 2001). In brief, 25 mL samples of urine were digested by refluxing and then heating to dryness in the presence of magnesium nitrate and concentrated nitric acid. Following magnesium nitrate digestion, samples were transferred to a muffle furnace and ashed at 500°C. The digested and ashed residue was dissolved in hydrochloric acid and analyzed by the hydride generation technique using a Perkin-Elmer 3100 atomic absorption spectrometer. Preliminary tests of this method established that each of the different forms of arsenic that may occur in urine, including trivalent inorganic arsenic (As+3), pentavalent inorganic arsenic (As+5), mono-methyl arsenic (MMA), and di-methyl arsenic (DMA), are all recovered with high efficiency. Urine analytical results are presented in Appendix A, Table A-7.

Laboratory Quality Assurance

A number of quality assurance (QA) steps were taken during this project to evaluate the accuracy of the analytical procedures. Steps performed by the analytical laboratory included:

Spike Recovery

Randomly selected urine samples were spiked with known amounts of arsenic (usually 5-10 μg, as sodium arsenate) and the recovery of the added arsenic was measured. Recovery for individual samples typically ranged from 101% to 110%, with an average across all analyses of 106 ± 3.2 % (N=15).

Duplicate Analysis

The laboratory analyst selected random urine samples for duplicate analysis. Duplicate results typically had a relative percent difference (RPD) of 0-13%, with an average of 2.2% (N=15).

Laboratory Control Standards

Samples of a urine standard were run with each set of test samples. The standard was obtained from ERA (sample number 99106) with a nominal arsenic concentration of 347 μg/L. Results for this standard ranged from 311 to 348 μg/L, with a mean across all samples of 328 ± 6.7 μg/L (N=38).

Blanks

Blank samples run along with each batch of samples never yielded a measurable level of arsenic, with all values being reported as less than 1 μg/L of arsenic.

Blind Quality Assurance Samples

In addition to these laboratory-sponsored QA procedures, an additional series of QA samples were submitted to the laboratory in a blind fashion. This included a number of Performance Evaluation (PE) samples (control urine spiked with a known amount of arsenic in the form of As+3, As+5, MMA, or DMA) and a number of blind duplicates.

The results for the PE samples are summarized in Figure 2-2. As seen, good recovery of the arsenic was demonstrated for all standards.

The results for blind duplicates are shown in Figure 2-3. As seen, there was good agreement between results for the duplicate pairs.

Based on the results of all of the quality assurance samples and steps described above, it is concluded that the analytical results for samples of urine are of high quality and are suitable for derivation of reliable estimates of arsenic absorption from test materials.

2.6.2 Feces

After drying, 1.0 gram of fecal material was removed and digested with 10 mL of magnesium nitrate and nitric acid using the same approach as described above for urine. Following digestion, all sample preparation and analytical steps are the same as for urine. Fecal analytical results are presented in Appendix A, Table A-8.

3.0 DATA ANALYSIS

Figure 3-1 shows a conceptual model for the toxicokinetic fate of ingested arsenic. Key points of this model are as follow:

- In most animals (including humans), absorbed arsenic is excreted mainly in the urine over the course of several days. Thus, the urinary excretion fraction (UEF), defined as the amount excreted in the urine divided by the amount given, is usually a reasonable approximation of the oral absorption fraction or ABA. However, this ratio will underestimate total absorption, because some absorbed arsenic is excreted in the feces via the bile, and some absorbed arsenic enters tissue compartments (e.g., skin, hair) from which it is cleared very slowly or not at all. Thus the urinary excretion fraction should not be equated with the absolute absorption fraction.

- The relative bioavailability (RBA) of two orally administered materials (e.g., a test material and reference material) can be calculated from the ratio of the urinary excretion fraction of the two materials. This calculation is independent of the extent of tissue binding and of biliary excretion:

$$RBA(test\ vs\ ref) = \frac{AF_o(test)}{AF_o(ref)} = \frac{D \cdot AF_o(test) \cdot K_u}{D \cdot AF_o(ref) \cdot K_u} = \frac{UEF(test)}{UEF(ref)}$$

Based on the conceptual model above, raw data from this study were reduced and analyzed as follows:

- The amount of arsenic excreted in urine by each animal over each collection period was calculated by multiplying the urine volume by the urine concentration:

  Excreted (μg/48hr) = Conc (μg/L) · Volume (L/48hr)

- For each test material, the amount of arsenic excreted by each animal was plotted as a function of the amount administered (μg/48 hours), and the best fit straight line (calculated by linear regression) through the data (μg excreted per μg administered) was used as the best estimate of the urinary excretion fraction (UEF).

- The relative bioavailability of arsenic in test material was calculated as:

  RBA = UEF(test) / UEF(NaAs)

  where sodium arsenate (NaAs) is used as the frame of reference.

- As noted above, each RBA value is calculated as the ratio of two slopes (UEFs), each of which is estimated by linear regression through a set of data points. Because of the variability in the data, there is uncertainty in the estimated slope (UEF) for each material. This uncertainty in the slope is described by the standard error of the mean (SEM) for the slope parameter. Given the best estimate and the SEM for each slope,

the uncertainty in the ratio may be estimated using Monte Carlo simulation. The probability density function (PDF) describing the confidence around each slope term (UEF) was assumed to be characterized by a t-distribution with n-2 degrees of freedom :

$$\frac{UEF(measured) - UEF(true)}{SEM} \sim t_{n-2}$$

For convenience, this PDF is abbreviated T(slope, sem, n), where slope = best estimate of the slope derived by linear regression, sem = standard deviation in the best estimate of the slope, and n = number of data points upon which the regression analysis was performed. Thus, the confidence distribution around each ratio was simulated as:

$$PDF(RBA) = \frac{T(slope, sem, n)_{test}}{T(slope, sem, n)_{ref}}$$

Using this equation, a Monte Carlo simulation was run for each RBA calculation. The 5th and 95th percentile values from the simulated distribution of RBA values were then taken to be the 90% confidence interval for the RBA.

4.0 RESULTS

4.1 Clinical Signs

The doses of arsenic administered in this study are below a level that is expected to cause toxicological responses in swine, and no clinical signs of arsenic-induced toxicity were noted in any of the animals used in this study.

4.2 Data Exclusions

Occasionally, the dilution of urine by spilled water was so large that the concentration of arsenic in the urine could not be quantified. These instances are defined by having a urine arsenic concentration at or below the quantitation limit (2 µg/L) and a total urine volume greater than 5000 mL. When both of these conditions were met, the data were deemed unreliable and excluded from further calculations. In this study, data from two animals in group 1 (pig #157 on days 6/7 and pig# 108 on days 10/11) were deemed unreliable for this reason and excluded. No additional urinary data were excluded.

4.3 Urinary Excretion Fractions and Relative Bioavailability

Detailed urinary results from this study are presented in Appendix A. The urinary excretion results for NaAs, Test Material 1, and Test Material 2 are summarized in Figures 4-1, 4-2, and 4-3, respectively. Although there is variability in the data, the dose-response curves are approximately linear, with the slope of the best-fit straight line being equal to the best estimate of the urinary excretion fraction (UEF). This finding is consistent with results from both animals and humans, which suggest that there is no threshold for arsenic absorption or excretion up to doses of at least 5,000 µg/day (USEPA, 1995).

As discussed above, the relative bioavailability of arsenic in a specific test material is calculated as follows:

RBA(test *vs* NaAs) = UEF(test) / UEF(NaAs,oral)

The following table summarizes the best fit slopes (urinary excretion fractions) for sodium arsenate and each of the test materials, as well as the RBA estimates:

Test Material	Slope (UEF) ± SEM	RBA (90% CI)
NaAs	0.907 ± 0.110 (43)	[1.00]
TM1 (8-37926)	0.154 ± 0.009 (41)	0.17 (0.14-0.22)
TM2 (BPSOU-0501-ASBIO)	0.202 ± 0.018 (43)	0.22 (0.17-0.29)

CI = Confidence Interval

As seen, using sodium arsenate as a relative frame of reference, the RBA estimate is 17% for TM1 and 22% for TM2. These RBA estimates are significantly lower than the default value of 80%-100% that is usually employed for arsenic in soil when reliable site-specific data are

lacking. This indicates that the arsenic in these soil samples is not as well absorbed as soluble arsenic, and it is appropriate to take this into account when evaluating potential risks to humans from incidental ingestion of these soils.

4.4 Fecal Excretion and Mass Balance

As shown in Figure 3-1, the amount of arsenic excreted in the feces is the sum of that which is ingested but never absorbed and that which is absorbed and then secreted in bile back into the intestines. Assuming that biliary excretion of absorbed arsenic is a relatively minor metabolic pathway, then the amount of arsenic excreted in the feces is expected to be high when the urinary excretion fraction (and hence the RBA) is low.

Detailed fecal data from this study are presented in Appendix A, Table A-8. Figure 4-4 shows the fecal excretion fraction (defined as the mass of arsenic excreted in feces in 48 hours divided by the oral dose of arsenic administered in 48 hours) as a function of the urinary excretion fraction. As seen, there is a clear negative trend, with low urinary excretion being associated with high fecal excretion.

The sum of the two excretion fractions is equal to the total fraction of the administered dose recovered in urine plus feces. These data are summarized below:

Test Material	UEF	FEF	Total
NaAs	0.907	0.051	0.958
TM1	0.154	0.638	0.793
TM2	0.202	0.692	0.894

As seen, the total fraction of the administered arsenic that was recovered in urine and feces averaged about 88% (range = 79%-96%). This recovery is consistent with most other studies of arsenic excretion in animals (USEPA, 1995).

5.0 DISCUSSION AND RECOMMENDATIONS

The RBA estimates for site soils collected from the Butte study area are about 0.17 and 0.22, with a mean of about 0.20. These values are both substantially less than the default value of 0.8 recommended by USEPA Region 8, supporting the conclusion that arsenic in Butte site soils is not as well absorbed as soluble arsenic. The detailed chemical mechanism accounting for this reduced bioavailability of arsenic in site soils is not known, but almost certainly is related to the chemical form of arsenic in the soils.

As mentioned in Section 2.1.1, Test Material 1 was tested previously in the swine bioassay system (USEPA, 1996) using an older analytical protocol that tended to have low recovery of organic arsenic. During that study, 24-hour urine samples were collected on Days 7 and 14, and the RBA was determined to be 0.06. Although this previous estimate is slightly lower than the estimate obtained in this study using the newer arsenic analysis method ($MgNO_3$ digestion) (0.17), both values support the conclusion that the RBA of TM1 is quite low compared to the USEPA default value (0.8). A comparison of the methods and results between the first and second analysis of TM1 is described in greater detail in a separate report (USEPA, 2003).

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TABLES

TABLE 2-1 STUDY DESIGN

Group	Number of Animals	Material Administered	Target Arsenic Dose (ug/kg-day)
1	3	Control	0
2	4	NaAs	25
3	4	NaAs	50
4	4	NaAs	75
5	4	Test Material 1	25
6	4	Test Material 1	50
7	4	Test Material 1	75
8	4	Test Material 2	25
9	4	Test Material 2	50
10	4	Test Material 2	75

TABLE 2-2 COMPOSITION OF TEST MATERIALS

Analyte	Concentration (mg/kg)	
	TM1	TM2
Aluminum	7970	14067
Antimony	6.2	3.4
Arsenic	251*	367**
Barium	142	211
Beryllium	0.61	0.78
Cadmium	43.1	7.7
Calcium	16100	3363
Chromium	7.4	25.6
Cobalt	9.6	8.7
Copper	871	3130
Iron	52100	39800
Lead	8640	492
Magnesium	3090	3950
Manganese	13500	732
Mercury	2.1	0.4
Nickel	9	12
Potassium	3640	3680
Selenium	0.28	0.91
Silver	42.3	8.1
Sodium	537	777
Thallium	1.8	0.8
Vanadium	30	49
Zinc	12500	2457

* Based on quadruplicate analyses via ICP
** Based on triplicate analyses via ICP

FIGURES

FIGURE 2-1 BODY WEIGHTS OF TEST ANIMALS

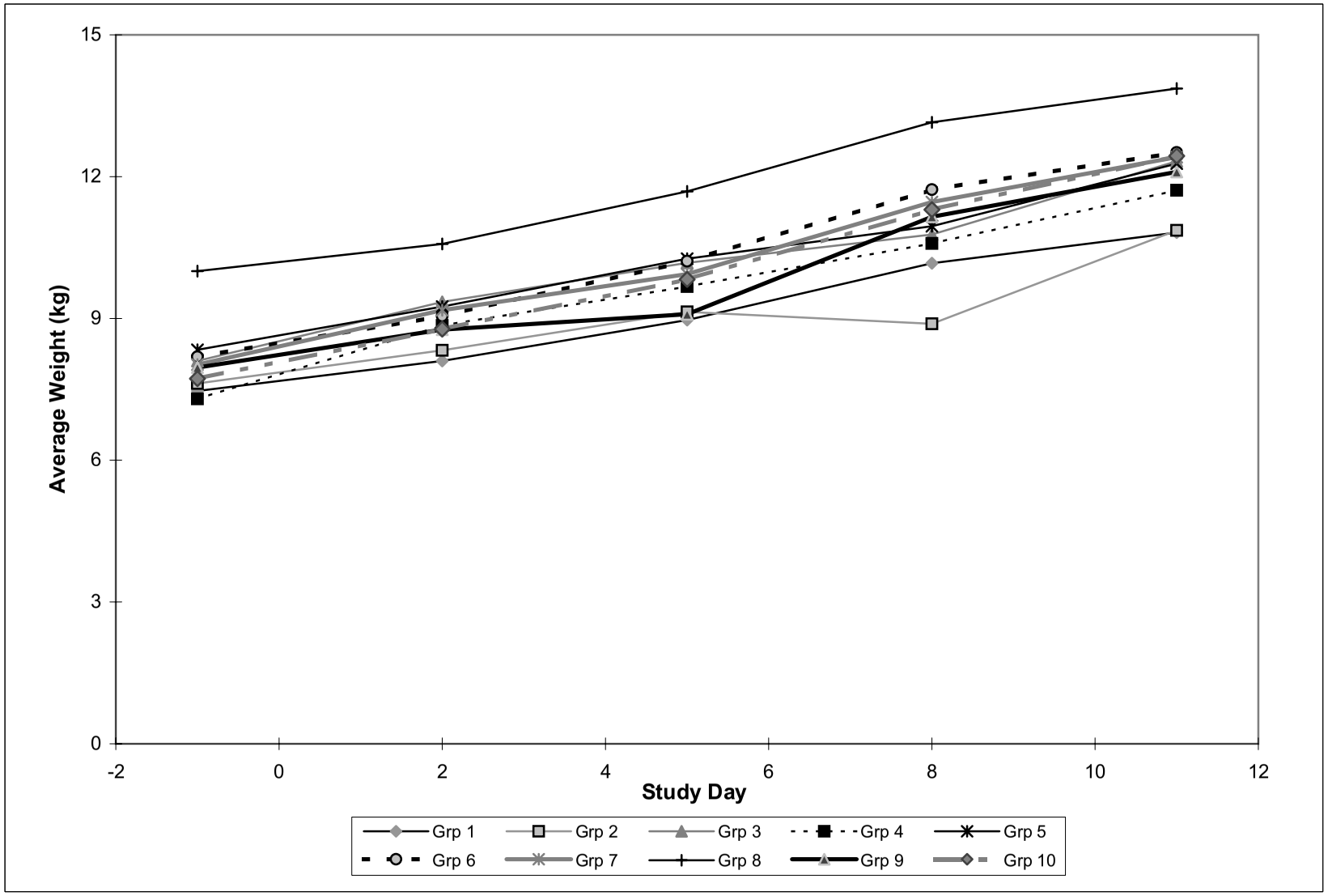
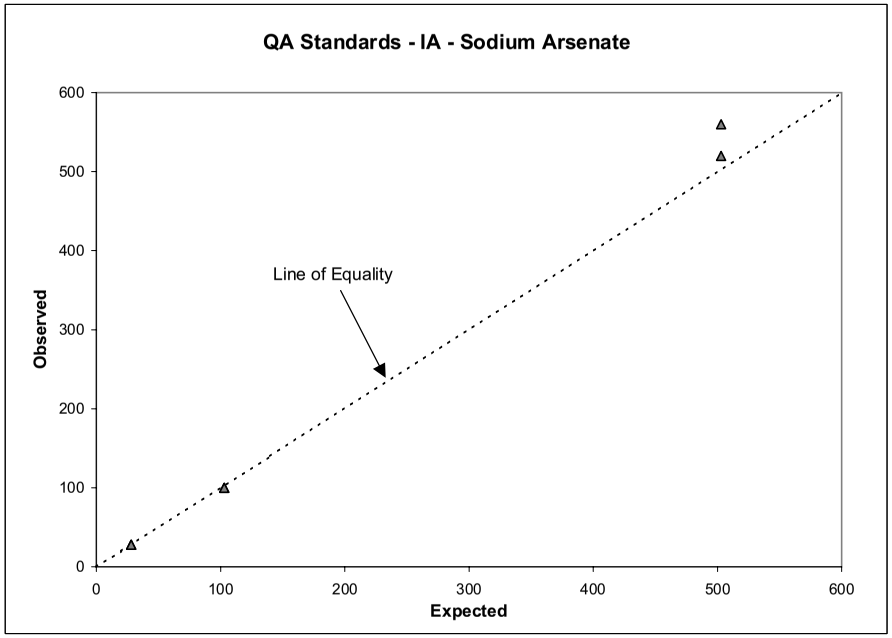
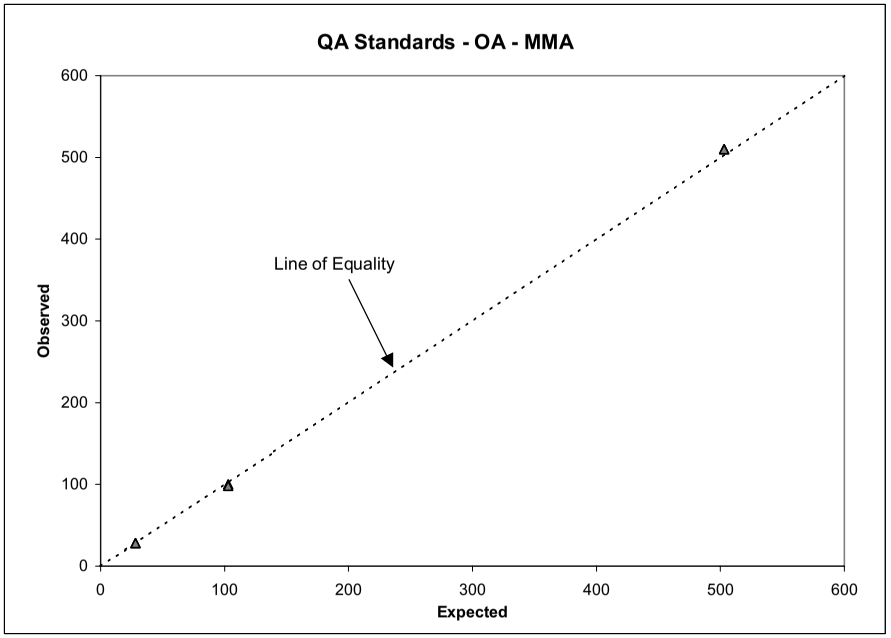
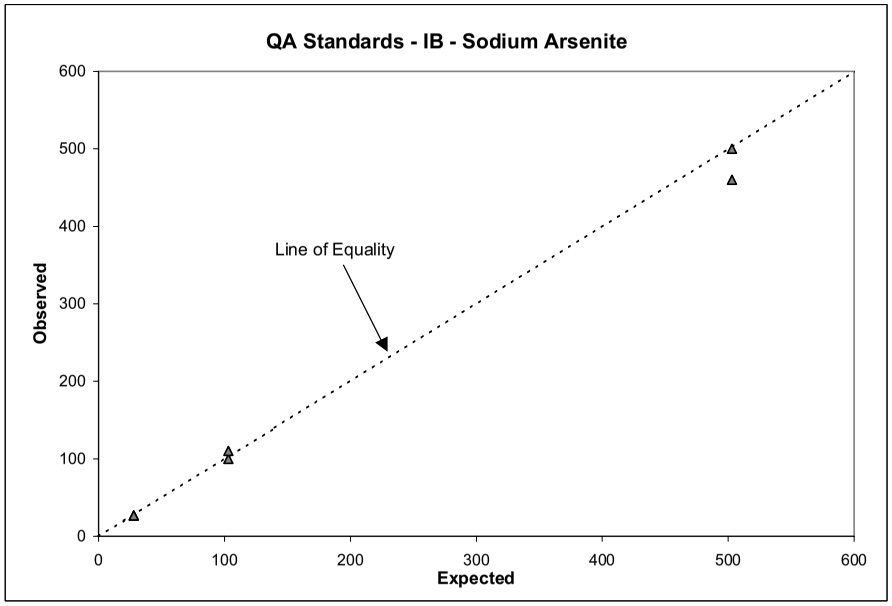


FIGURE 2-2 PERFORMANCE EVALUATION SAMPLES







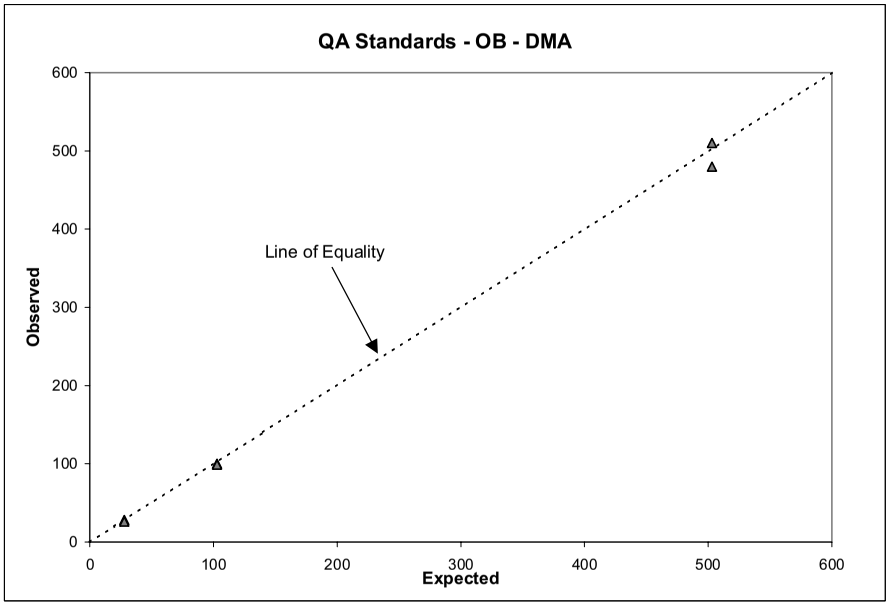


FIGURE 2-3 BLIND DUPLICATE SAMPLES FOR URINE

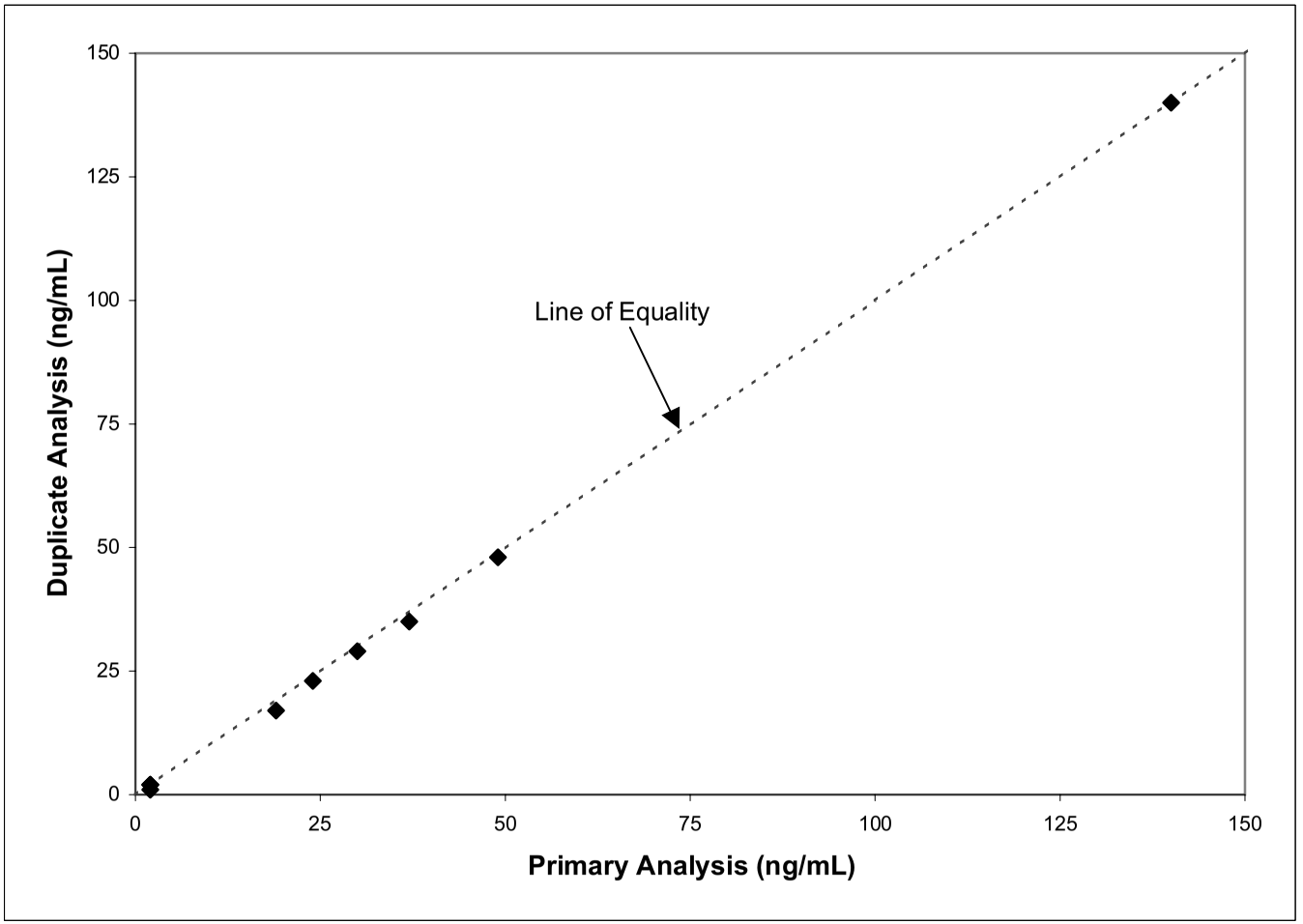
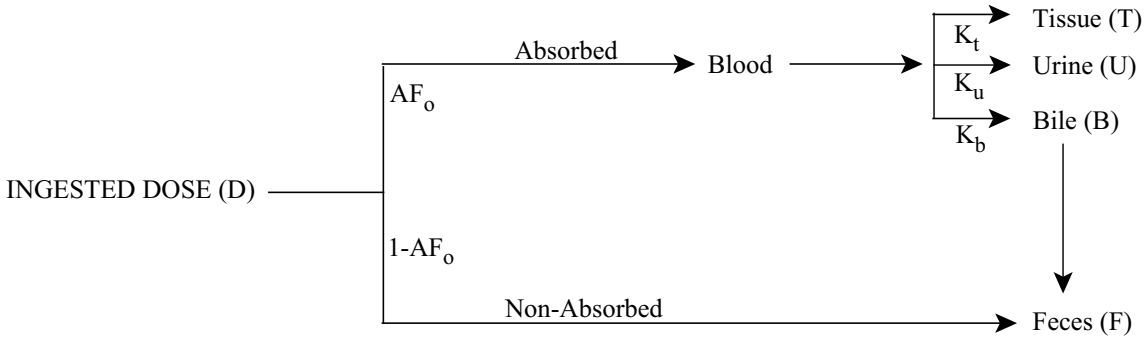


Figure 3-1. Conceptual Model for Arsenic Toxicokinetics



where:

D = Ingested dose (ug)
AF_o = Oral Absorption Fraction
K_t = Fraction of absorbed arsenic which is retained in tissues
K_u = Fraction of absorbed arsenic which is excreted in urine
K_b = Fraction of absorbed arsenic which is excreted in the bile

BASIC EQUATIONS:

Amount Absorbed (ug) $= D \cdot AF_o$

Amount Excreted (ug) $=$ Amount absorbed $\cdot K_u$

$= D \cdot AF_o \cdot K_u$

Urinary Excretion Fraction (UEF) $=$ Amount excreted / Amount Ingested

$= (D \cdot AF_o \cdot K_u) / D$

$= AF_o \cdot K_u$

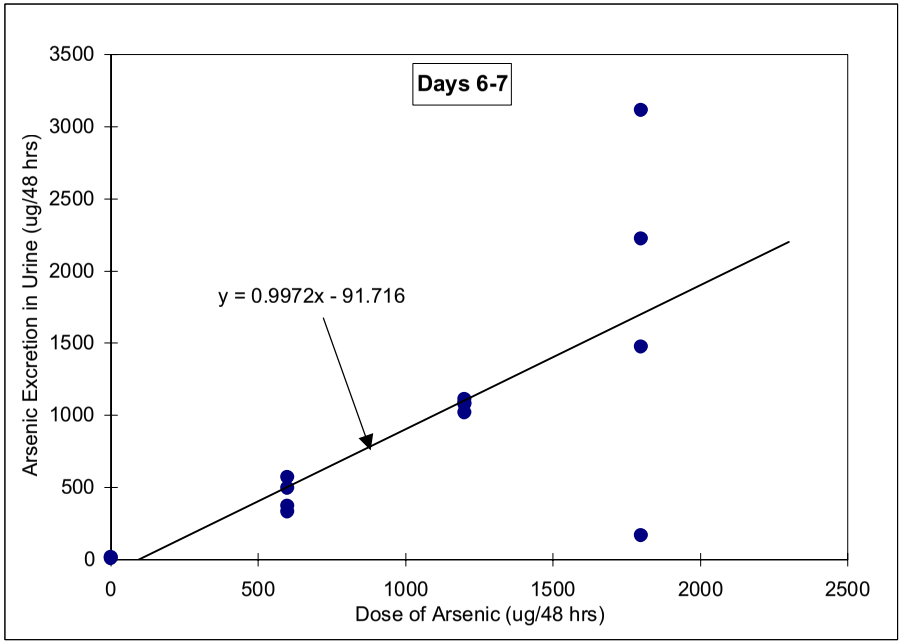
Relative Bioavailability (x vs. y) $= UEF(x) / UEF(y)$

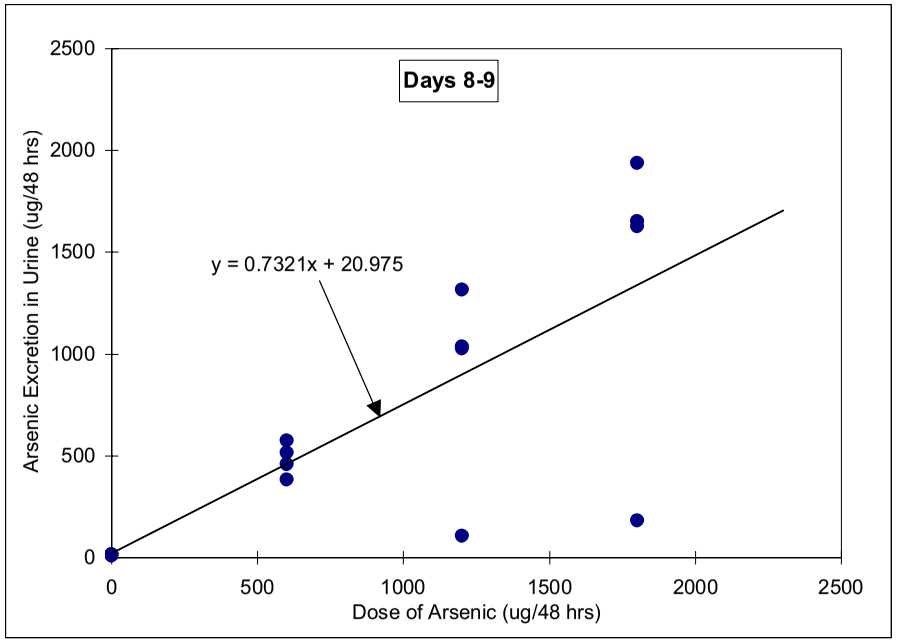
$= (AF_o(x) \cdot K_u) / (AF_o(y) \cdot K_u)$

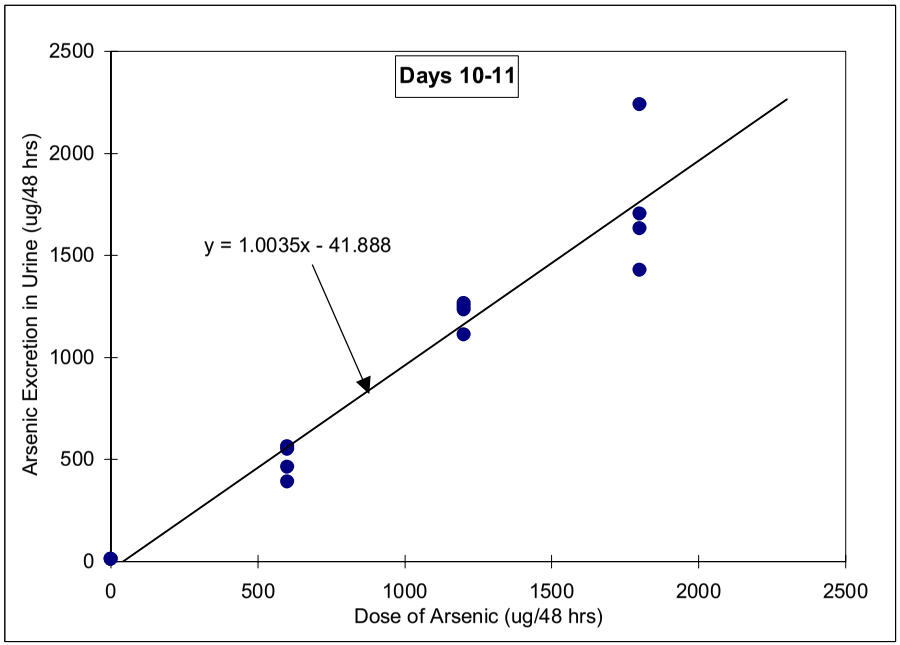
$= AF_o(x) / AF_o(y)$

Fig 3-1_Toxicokinetics.wpd

FIGURE 4-1 URINARY EXCRETION OF ARSENIC FROM SODIUM ARSENATE







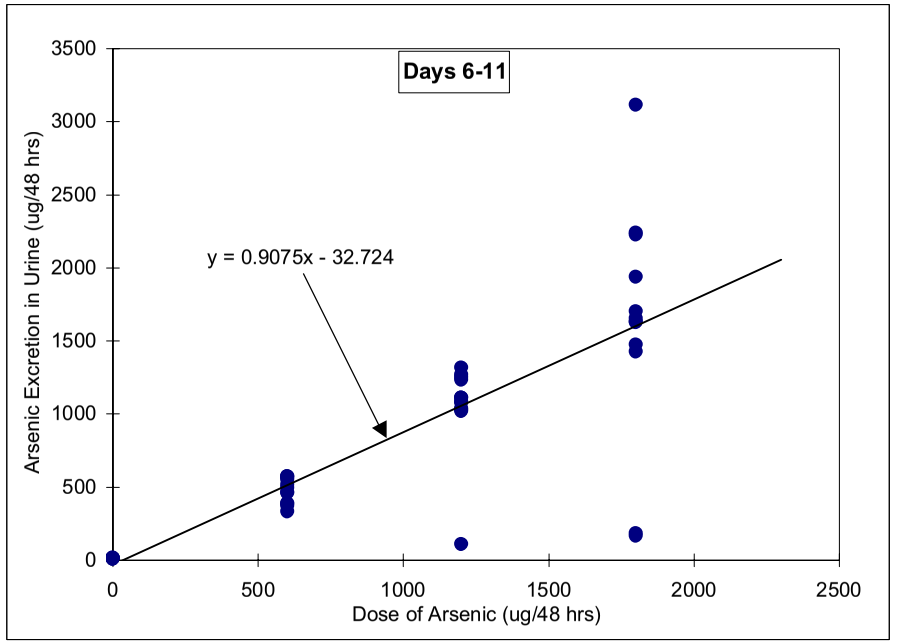


FIGURE 4-2 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 1

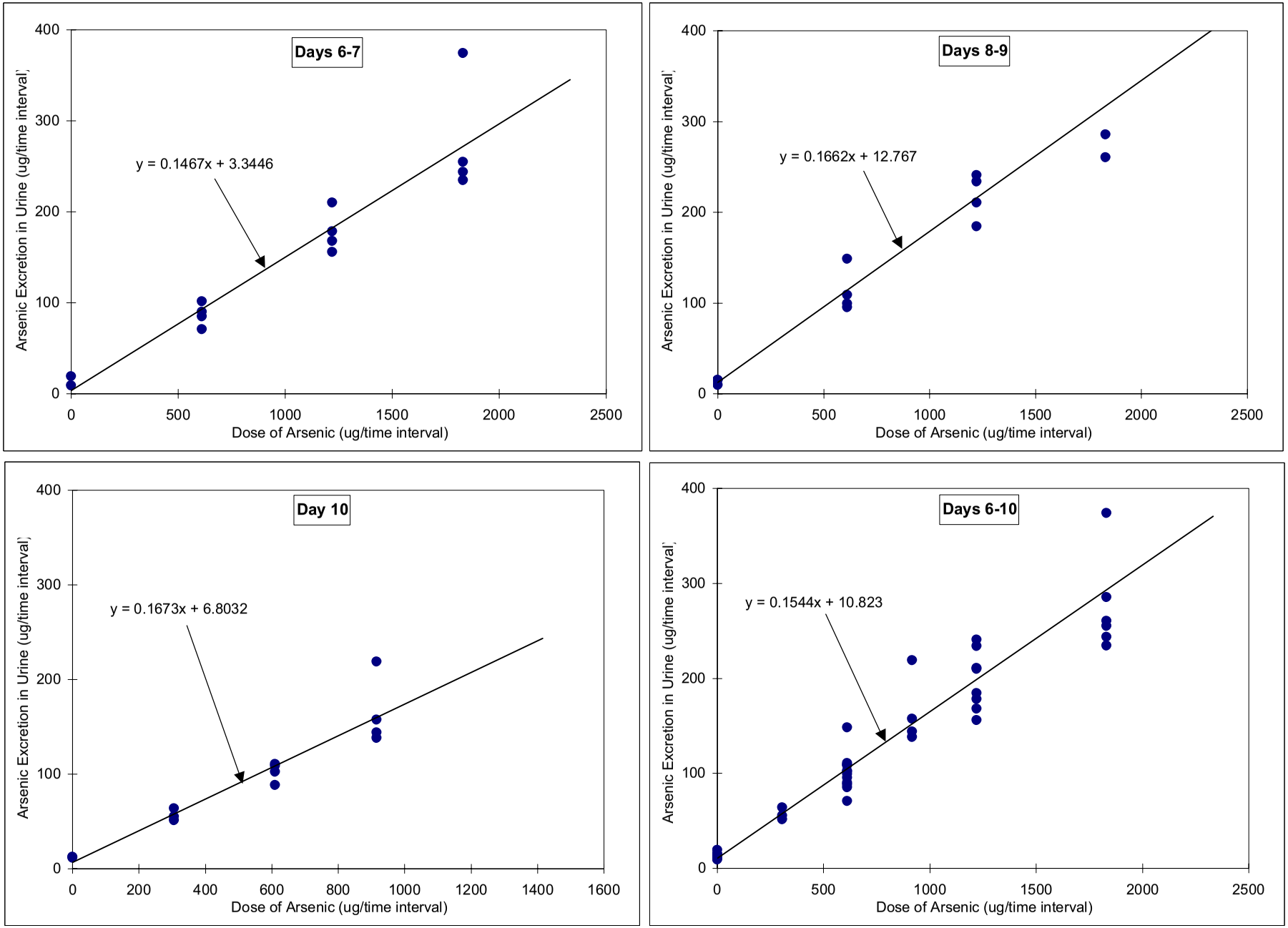


FIGURE 4-3 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 2

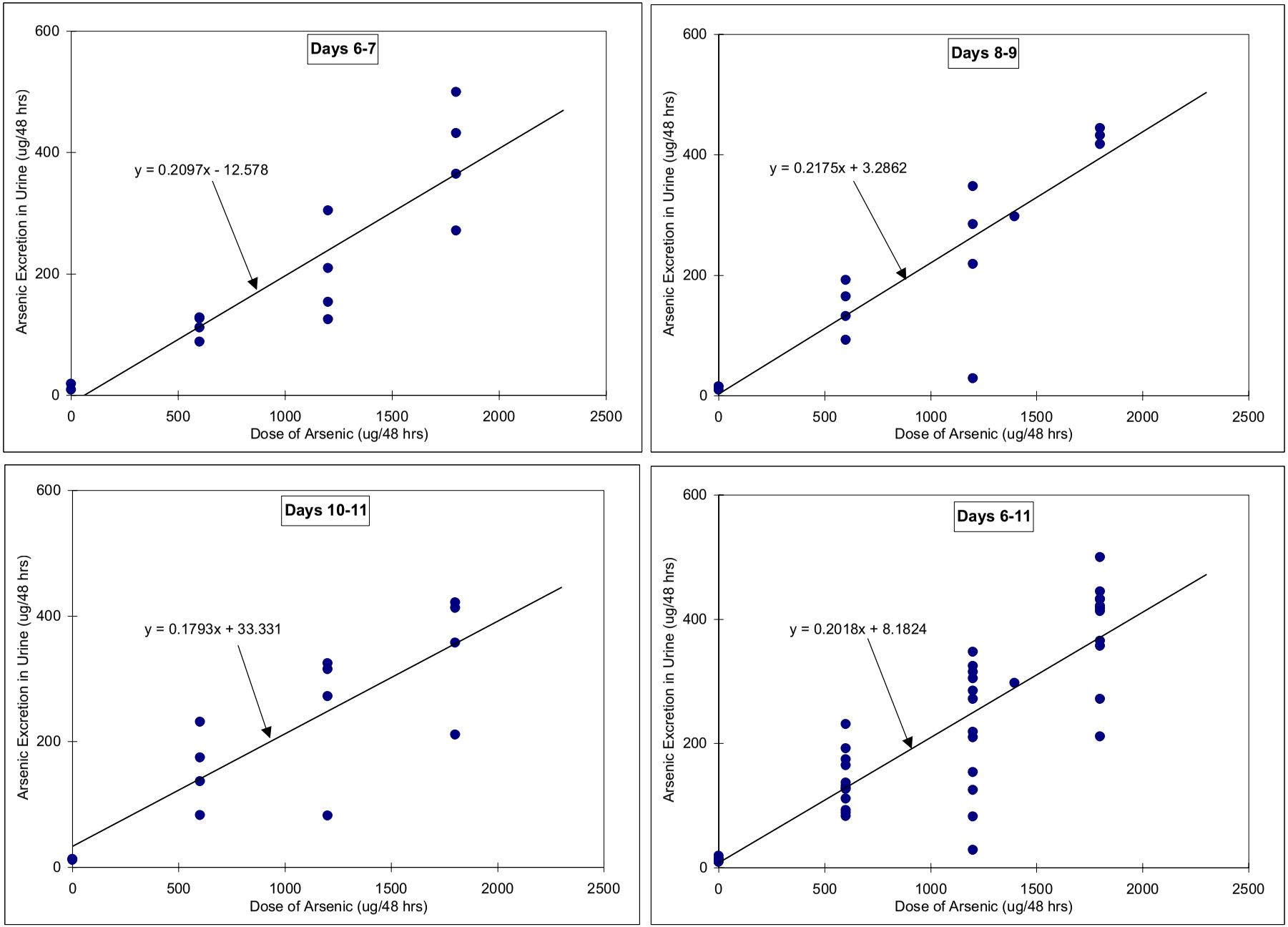
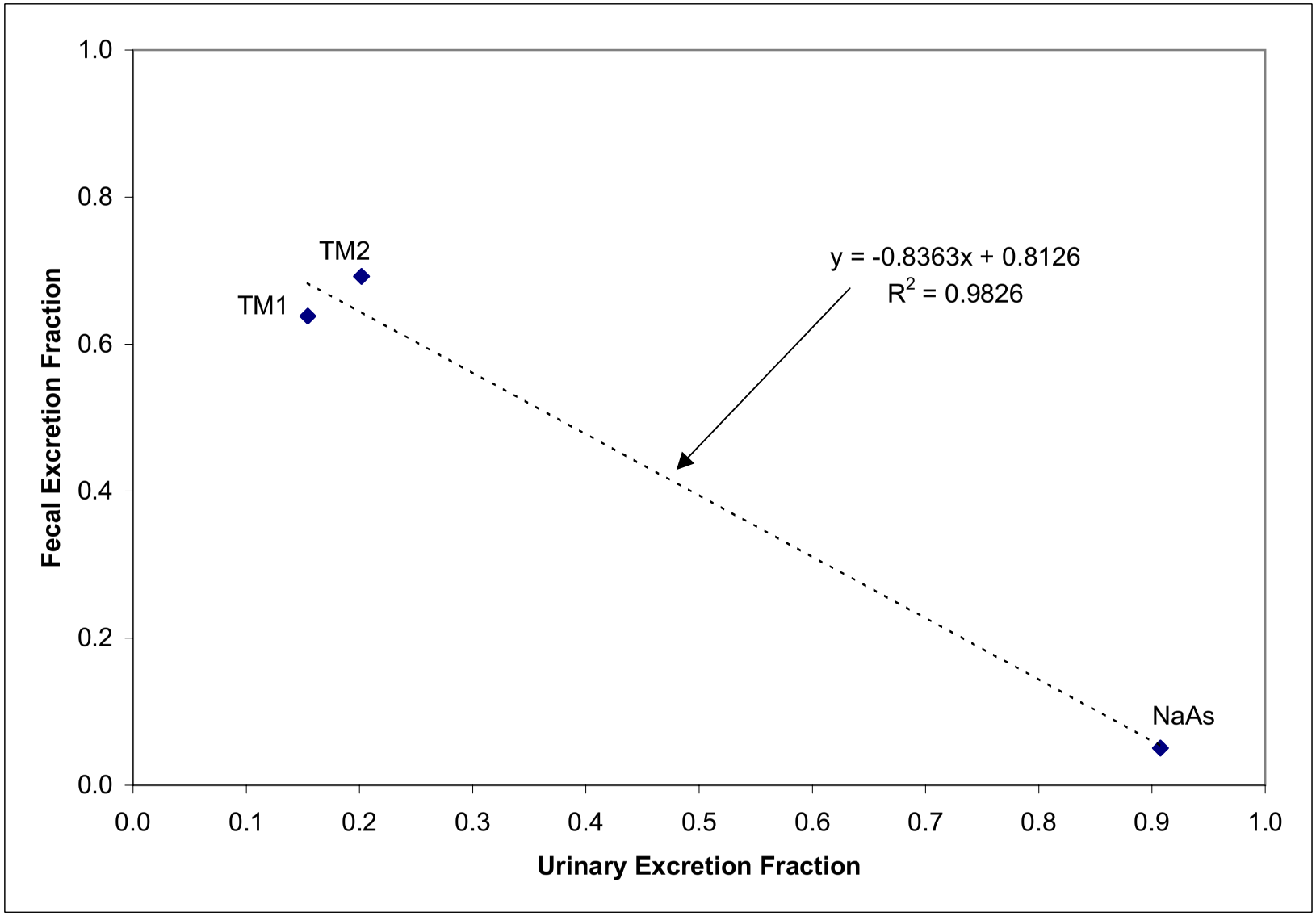


FIGURE 4-4 URINARY EXCRETION FRACTION VS. FECAL EXCRETION FRACTION



APPENDIX A

DETAILED STUDY RESULTS

TABLE A-1 SCHEDULE

Study Day	Day	Date	Dose Administration	Feed	Weigh	Dose Prep	Cull Pigs/Assign Dose Group	48 hr Urine Collection	Sacrifice
-4	Saturday	6/16/2001		X	X				
-3	Sunday	6/17/2001		X					
-2	Monday	6/18/2001		X			X		
-1	Tuesday	6/19/2001		X	X	X			
0	Wednesday	6/20/2001	X	X					
1	Thursday	6/21/2001	X	X					
2	Friday	6/22/2001	X	X	X				
3	Saturday	6/23/2001	X	X					
4	Sunday	6/24/2001	X	X					
5	Monday	6/25/2001	X	X	X				
6	Tuesday	6/26/2001	X	X					
7	Wednesday	6/27/2001	X	X					
8	Thursday	6/28/2001	X	X	X				
9	Friday	6/29/2001	X	X					
10	Saturday	6/30/2001	X	X					
11	Sunday	7/1/2001	X	X	X				
12	Monday	7/2/2001							X

TABLE A-2 GROUP ASSIGNMENTS

Pig Number	Group	Material Administered	Target Dose of Arsenic (ug/kg-day)
108	1	Control	0
145			
157			
122	2	NaAs	25
123			
147			
156			
101	3	NaAs	50
115			
119			
151			
121	4	NaAs	75
136			
140			
148			
104	5	TM1	25
106			
128			
155			
103	6	TM1	50
110			
116			
142			
120	7	TM1	75
125			
138			
150			
102	8	TM2	25
114			
117			
126			
112	9	TM2	50
113			
135			
154			
124	10	TM2	75
133			
158			
160			

TABLE A-3. BODY WEIGHTS AND ADMINISTERED DOSES, BY DAY

Body weights were measured on days -1, 2, 5, 8, 11. Weights for other days are estimated, based on linear interpolation between measured values.

Group	ID #	Day -1		Day 0		Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7		Day 8		Day 9		Day 10		Day 11	
		BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day
1	108	7.35	0	7.5	0	7.6	0	7.75	0	7.9	0	8.1	0	8.3	0	8.8	0	9.2	0	9.65	0	9.8	0	10.0	0	10.15	0
1	145	7.8	0	7.9	0	8.1	0	8.2	0	8.6	0	9.0	0	9.45	0	9.8	0	10.1	0	10.35	0	10.7	0	11.0	0	11.25	0
1	157	7.25	0	7.6	0	8.0	0	8.35	0	8.6	0	8.9	0	9.15	0	9.6	0	10.1	0	10.5	0	10.7	0	10.9	0	11.05	0
2	122	8.1	0	8.4	300	8.7	300	8.95	300	9.3	300	9.7	300	10.05	300	9.4	300	8.8	300	8.15	300	9.6	300	11.1	300	12.5	300
2	123	7.25	0	7.6	300	7.9	300	8.25	300	8.6	300	9.0	300	9.4	300	9.7	300	10.0	300	10.35	300	10.7	300	11.0	300	11.3	300
2	147	7.85	0	8.0	300	8.1	300	8.15	300	8.4	300	8.6	300	8.8	300	8.8	300	8.8	300	8.85	300	9.3	300	9.8	300	10.2	300
2	156	7.3	0	7.5	300	7.7	300	7.95	300	8.1	300	8.2	300	8.3	300	8.3	300	8.2	300	8.2	300	8.6	300	9.0	300	9.45	300
3	101	7.75	0	8.4	600	9.1	600	9.8	600	10.2	600	10.6	600	10.95	600	11.2	600	11.4	600	11.55	600	12.2	600	12.8	600	13.35	600
3	115	7.55	0	8.0	600	8.4	600	8.85	600	9.2	600	9.5	600	9.8	600	9.9	600	9.9	600	10	600	10.6	600	11.2	600	11.75	600
3	119	9	0	9.3	600	9.5	600	9.8	600	10.0	600	10.3	600	10.5	600	10.6	600	10.6	600	10.7	600	11.5	600	12.2	600	12.95	600
3	151	8.1	0	8.4	600	8.7	600	8.95	600	9.1	600	9.3	600	9.45	600	9.9	600	10.4	600	10.85	600	11.0	600	11.1	600	11.25	600
4	121	5.15	0	6.03	900	6.9	900	7.8	900	8.0	900	8.1	900	8.3	900	9.0	900	9.6	900	10.3	900	10.5	900	10.7	900	10.85	900
4	136	9.35	0	9.5	900	9.6	900	9.75	900	10.2	900	10.6	900	10.95	900	11.2	900	11.4	900	11.6	900	12.0	900	12.4	900	12.8	900
4	140	6.95	0	7.6	900	8.2	900	8.75	900	9.0	900	9.2	900	9.4	900	9.4	900	9.4	900	9.4	900	10.0	900	10.6	900	11.2	900
4	148	7.75	0	8.2	900	8.7	900	9.1	900	9.4	900	9.7	900	10.05	900	10.4	900	10.7	900	11.05	900	11.4	900	11.7	900	12	900
5	104	8.55	0	8.8	305	9.0	305	9.15	305	9.5	306	9.9	306	10.3	306	10.3	306	10.3	306	10.3	306	10.9	306	11.5	306	12.15	306
5	106	8.6	0	8.7	305	8.7	305	8.8	305	9.2	306	9.5	306	9.85	306	10.5	306	11.1	306	11.65	306	11.9	306	12.2	306	12.4	306
5	128	8.85	0	9.4	305	9.9	305	10.45	305	10.8	306	11.1	306	11.35	306	11.0	306	10.7	306	10.3	306	11.1	306	11.9	306	12.7	306
5	155	7.35	0	7.8	305	8.2	305	8.6	305	8.9	306	9.2	306	9.55	306	10.2	306	10.9	306	11.55	306	11.7	306	11.8	306	11.85	306
6	103	7.35	0	7.6	610	7.8	610	8.05	610	8.4	611	8.8	611	9.2	611	9.7	611	10.1	611	10.6	611	10.9	611	11.2	611	11.5	611
6	110	8.5	0	9.1	610	9.7	610	10.35	610	10.7	611	11.1	611	11.45	611	12.0	611	12.5	611	12.95	611	13.3	611	13.6	611	13.95	611
6	116	9.6	0	9.8	610	10.0	610	10.15	610	10.7	611	11.2	611	11.75	611	12.4	611	13.0	611	13.6	611	13.8	611	14.1	611	14.3	611
6	142	7.3	0	7.4	610	7.5	610	7.65	610	7.9	611	8.2	611	8.45	611	8.9	611	9.3	611	9.75	611	9.9	611	10.1	611	10.3	611
7	120	6.9	0	7.8	916	8.6	916	9.45	916	10.0	917	10.6	917	11.15	917	11.5	917	11.8	917	12.05	917	12.4	917	12.7	917	12.95	917
7	125	8.85	0	9.3	916	9.7	916	10.05	916	9.8	917	9.6	917	9.4	917	10.4	917	11.4	917	12.35	917	12.6	917	12.9	917	13.15	917
7	138	8.6	0	8.7	916	8.8	916	8.9	916	9.0	917	9.0	917	9.05	917	9.7	917	10.4	917	11.05	917	11.6	917	12.1	917	12.55	917
7	150	7.75	0	7.9	916	8.1	916	8.3	916	8.9	917	9.5	917	10.15	917	10.2	917	10.3	917	10.4	917	10.6	917	10.8	917	11	917
8	102	8.75	0	8.9	300	9.1	300	9.3	300	10.2	300	11.0	300	11.85	300	11.5	300	11.1	300	10.7	300	11.0	300	11.4	300	11.7	300
8	114	10.1	0	10.4	300	10.6	300	10.9	300	11.3	300	11.8	300	12.2	300	12.8	300	13.5	300	14.1	300	14.3	300	14.6	300	14.8	300
8	117	10.5	0	10.7	300	11.0	300	11.2	300	11.5	300	11.7	300	11.95	300	12.5	300	13.1	300	13.65	300	13.9	300	14.1	300	14.3	300
8	126	10.65	0	10.7	300	10.8	300	10.9	300	10.9	300	10.8	300	10.75	300	11.9	300	13.0	300	14.15	300	14.3	300	14.5	300	14.65	300
9	112	8.75	0	8.9	600	9.1	600	9.3	600	10.2	600	11.0	600	11.85	600	11.5	600	11.1	600	10.7	600	11.0	600	11.4	600	11.7	600
9	113	10.1	0	10.4	600	10.6	600	10.9	600	11.3	600	11.8	600	12.2	600	12.8	600	13.5	600	14.1	600	14.3	600	14.6	600	14.8	600
9	135	10.5	0	10.7	600	11.0	600	11.2	600	11.5	600	11.7	600	11.95	600	12.5	600	13.1	600	13.65	600	13.9	600	14.1	600	14.3	600
9	154	10.65	0	10.7	600	10.8	600	10.9	600	10.9	600	10.8	600	10.75	600	11.9	600	13.0	600	14.15	600	14.3	600	14.5	600	14.65	600
10	124	8.5	0	9.0	900	9.5	900	10	900	9.7	900	9.5	900	9.21	900	10.5	900	11.8	900	13.1	900	13.3	900	13.4	900	13.55	900
10	133	7.15	0	7.4	900	7.6	900	7.8	900	8.3	900	8.8	900	9.25	900	9.6	900	9.9	900	10.2	900	10.5	900	10.8	900	11.15	900
10	158	8.55	0	8.8	900	9.0	900	9.25	900	9.3	900	9.3	900	9.35	900	10.1	900	10.9	900	11.6	900	11.9	900	12.2	900	12.5	900
10	160	7.65	0	7.8	900	7.9	900	8	900	8.2	900	8.4	900	8.55	900	8.9	900	9.3	900	9.7	900	10.2	900	10.7	900	11.2	900

TABLE A-4 BODY WEIGHT ADJUSTED DOSES (ug/kg-day)

(Dose for Day/BW for Day)

Group	Pig #	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Avg Dose	Avg Dose per Group
1	108	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1	145	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1	157	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
2	122	35.79	34.62	33.52	32.20	30.98	29.85	31.86	34.16	36.81	31.25	27.15	24.00	31.85	
2	123	39.56	37.89	36.36	34.75	33.27	31.91	30.87	29.90	28.99	28.13	27.31	26.55	32.13	
2	147	37.74	37.27	36.81	35.86	34.95	34.09	34.03	33.96	33.90	32.26	30.77	29.41	34.25	
2	156	39.91	38.79	37.74	37.19	36.66	36.14	36.29	36.44	36.59	34.82	33.21	31.75	36.29	33.63
3	101	71.15	65.81	61.22	58.92	56.78	54.79	53.81	52.86	51.95	49.38	47.06	44.94	55.72	
3	115	75.16	71.29	67.80	65.45	63.27	61.22	60.81	60.40	60.00	56.69	53.73	51.06	62.24	
3	119	64.75	62.94	61.22	59.80	58.44	57.14	56.78	56.43	56.07	52.40	49.18	46.33	56.79	
3	151	71.57	69.23	67.04	65.81	64.63	63.49	60.50	57.78	55.30	54.63	53.97	53.33	61.44	59.05
4	121	149.17	130.12	115.38	112.97	110.66	108.43	100.37	93.43	87.38	85.85	84.38	82.95	105.09	
4	136	94.90	93.59	92.31	88.67	85.31	82.19	80.60	79.06	77.59	75.00	72.58	70.31	82.68	
4	140	119.21	110.43	102.86	100.37	98.00	95.74	95.74	95.74	95.74	90.00	84.91	80.36	97.43	
4	148	109.76	104.05	98.90	95.58	92.47	89.55	86.68	83.98	81.45	79.18	77.03	75.00	89.47	93.66
5	104	34.88	34.10	33.36	32.05	30.81	29.66	29.66	29.66	29.66	27.99	26.49	25.15	30.29	
5	106	35.22	34.95	34.68	33.39	32.16	31.02	29.24	27.65	26.23	25.68	25.15	24.64	30.00	
5	128	32.53	30.78	29.21	28.42	27.65	26.92	27.78	28.69	29.66	27.53	25.68	24.06	28.24	
5	155	39.30	37.30	35.49	34.27	33.09	31.99	29.91	28.07	26.45	26.23	26.00	25.78	31.16	29.92
6	103	80.50	78.09	75.83	72.46	69.31	66.42	63.22	60.30	57.65	56.06	54.56	53.14	65.63	
6	110	66.96	62.72	58.98	57.02	55.14	53.37	51.14	49.08	47.19	46.00	44.88	43.81	53.02	
6	116	62.40	61.25	60.14	57.20	54.48	52.01	49.41	47.07	44.93	44.17	43.44	42.73	51.60	
6	142	82.31	81.03	79.80	77.19	74.67	72.32	68.79	65.59	62.68	61.52	60.40	59.33	70.47	60.18
7	120	118.15	106.47	96.89	91.51	86.61	82.21	80.06	78.01	76.07	74.22	72.46	70.78	86.12	
7	125	98.99	94.89	91.11	93.22	95.32	97.51	88.28	80.64	74.22	72.65	71.15	69.71	85.64	
7	138	105.25	104.05	102.88	102.42	101.85	101.29	94.34	88.28	82.95	79.36	76.07	73.04	92.65	
7	150	115.42	112.81	110.32	102.80	96.15	90.31	89.57	88.85	88.14	86.47	84.87	83.33	95.75	90.04
8	102	33.58	32.91	32.26	29.56	27.27	25.32	26.16	27.07	28.04	27.19	26.39	25.64	28.45	
8	114	28.94	28.21	27.52	26.47	25.50	24.59	23.38	22.28	21.28	20.93	20.59	20.27	24.16	
8	117	27.95	27.36	26.79	26.20	25.64	25.10	23.97	22.93	21.98	21.63	21.30	20.98	24.32	
8	126	27.95	27.73	27.52	27.65	27.78	27.91	25.25	23.05	21.20	20.95	20.71	20.48	24.85	25.44
9	112	67.16	65.81	64.52	59.11	54.55	50.63	52.33	54.14	56.07	54.38	52.79	51.28	56.90	
9	113	57.88	56.43	55.05	52.94	50.99	49.18	46.75	44.55	42.55	41.86	41.19	40.54	48.33	
9	135	55.90	54.71	53.57	52.40	51.28	50.21	47.94	45.86	43.96	43.27	42.60	41.96	48.64	
9	154	55.90	55.47	55.05	55.30	55.56	55.81	50.49	46.09	42.40	41.91	41.43	40.96	49.70	50.89
10	124	100.00	94.74	90.00	92.43	95.00	97.72	85.66	76.25	68.70	67.92	67.16	66.42	83.50	
10	133	122.17	118.68	115.38	108.65	102.66	97.30	94.08	91.06	88.24	85.58	83.08	80.72	98.97	
10	158	102.47	99.82	97.30	96.95	96.60	96.26	89.11	82.95	77.59	75.63	73.77	72.00	88.37	
10	160	115.88	114.16	112.50	109.98	107.57	105.26	100.75	96.60	92.78	88.24	84.11	80.36	100.68	92.88

TABLE A-5 URINE VOLUMES - 48 HOUR COLLECTIONS

Units of Volume: mL

Group	Pig #	Day		
		6-7 6/26-6/28	**8-9** 6/28-6/30	**10-11** 6/30-7/2
1	108	9580	4800	13600
	145	4640	5000	5800
	157	10100	7500	6400
2	122	6980	7000	6200
	123	24780	28600	28200
	147	4880	9000	5800
	156	5120	4800	4500
3	101	14360	3470	59500
	115	35820	35600	35200
	119	3000	3800	2780
	151	3620	4500	6500
4	121	8420	1400	16000
	136	2364	14800	14200
	140	9840	11800	14840
	148	12360	14900	10200
5	104	3700	6400	2700
	106	3720	6200	2400
	128	7820	10600	5000
	155	3920	5600	3200
6	103	9740	9700	4200
	110	8100	8600	3200
	116	14000	15600	6500
	142	14000	7800	3100
7	120	5720	9800	3500
	125	15590	21200	14600
	138	6960	3100	1200
	150	10200	8400	6000
8	102	4640	6200	5200
	114	8520	11000	9200
	117	10560	11000	17800
	126	20640	29600	42860
9	112	8700	11400	13000
	113	11040	1600	16600
	135	6940	9400	14000
	154	2300	7800	6800
10	124	3800	5400	6400
	133	7200	7200	8600
	158	1940	4800	4300
	160	7240	7800	7600

= Volumes are for a 24-hour collection on Day 10.

TABLE A-6 FECAL WEIGHTS - 48 HOUR COLLECTIONS

Units of Weight: grams

Group	Pig ID	Day		
		6-7 6/26-6/28	**8-9** 6/28-6/30	**10-11** 6/30-7/2
1	108	284.8	290.9	363.7
	145	265.6	240.2	305.8
	157	225.9	395.9	4568.9
2	122	301.1	340.8	296.2
	123	264.9	243	311.3
	147	228.6	373.5	171.4
	156	missing	86.2	259.8
3	101	372.8	303.2	376.2
	115	321.9	305.8	305.9
	119	300.3	569.7	360.6
	151	289	465	380.7
4	121	381.4	392.8	347
	136	522.5	342	365.7
	140	31.9	414	212.4
	148	227.4	316.7	331
5	104	317.7	411.1	366.4
	106	236.3	558.3	213.2
	128	359.7	354.4	218.1
	155	436.3	356	145.1
6	103	211.3	412.4	291.8
	110	265.1	526	218.9
	116	361.8	652	356.7
	142	276.1	401.1	243.5
7	120	296.8	432	204.1
	125	373.4	428.1	264.3
	138	640.3	381.7	268.2
	150	333.9	405.8	253.5
8	102	337.9	438.5	240.9
	114	361.8	403.2	244.2
	117	387.1	376.5	198
	126	543.2	489.3	363.2
9	112	582.8	541.5	275
	113	602.9	413.3	384.5
	135	443.8	364	165.1
	154	498.1	467.3	372.6
10	124	490.2	341.2	368.9
	133	483.9	506.6	190.7
	158	534	265.1	369.5
	160	192.6	327	268.3

= Weights are for a 24-hour collection on Day 10.

TABLE A-7 URINE ANALYTICAL RESULTS

ID	pig number	group	dosage	day	date collected	sample number	tag number2	MgNO3 Q	MgNO3 ng/mL
1	108	1	0	6/7	26-Jun-01	BA1-108-(6/7)-U	BA-01-00205		2
2	145	1	0	6/7	26-Jun-01	BA1-145-(6/7)-U	BA-01-00209		2
3	157	1	0	6/7	26-Jun-01	BA1-157-(6/7)-U	BA-01-00232		2
4	122	2	25	6/7	26-Jun-01	BA1-122-(6/7)-U	BA-01-00238		82
5	123	2	25	6/7	26-Jun-01	BA1-123-(6/7)-U	BA-01-00187		20
6	147	2	25	6/7	26-Jun-01	BA1-147-(6/7)-U	BA-01-00192		68
7	156	2	25	6/7	26-Jun-01	BA1-156-(6/7)-U	BA-01-00222		73
8	101	3	50	6/7	26-Jun-01	BA1-101-(6/7)-U	BA-01-00190		71
9	115	3	50	6/7	26-Jun-01	BA1-115-(6/7)-U	BA-01-00195		30
10	119	3	50	6/7	26-Jun-01	BA1-119-(6/7)-U	BA-01-00210		370
11	151	3	50	6/7	26-Jun-01	BA1-151-(6/7)-U	BA-01-00233		300
12	121	4	75	6/7	26-Jun-01	BA1-121-(6/7)-U	BA-01-00188		370
13	136	4	75	6/7	26-Jun-01	BA1-136-(6/7)-U	BA-01-00189		71
14	140	4	75	6/7	26-Jun-01	BA1-140-(6/7)-U	BA-01-00213		150
15	148	4	75	6/7	26-Jun-01	BA1-148-(6/7)-U	BA-01-00204		180
16	104	5	25	6/7	26-Jun-01	BA1-104-(6/7)-U	BA-01-00208		23
17	106	5	25	6/7	26-Jun-01	BA1-106-(6/7)-U	BA-01-00198		19
18	128	5	25	6/7	26-Jun-01	BA1-128-(6/7)-U	BA-01-00186		13
19	155	5	25	6/7	26-Jun-01	BA1-155-(6/7)-U	BA-01-00203		23
20	103	6	50	6/7	26-Jun-01	BA1-103-(6/7)-U	BA-01-00217		16
21	110	6	50	6/7	26-Jun-01	BA1-110-(6/7)-U	BA-01-00184		22
22	116	6	50	6/7	26-Jun-01	BA1-116-(6/7)-U	BA-01-00215		15
23	142	6	50	6/7	26-Jun-01	BA1-142-(6/7)-U	BA-01-00219		12
24	120	7	75	6/7	26-Jun-01	BA1-120-(6/7)-U	BA-01-00197		41
25	125	7	75	6/7	26-Jun-01	BA1-125-(6/7)-U	BA-01-00220		24
26	138	7	75	6/7	26-Jun-01	BA1-138-(6/7)-U	BA-01-00236		35
27	150	7	75	6/7	26-Jun-01	BA1-150-(6/7)-U	BA-01-00216		25
28	102	8	25	6/7	26-Jun-01	BA1-102-(6/7)-U	BA-01-00201		19
29	114	8	25	6/7	26-Jun-01	BA1-114-(6/7)-U	BA-01-00234		15
30	117	8	25	6/7	26-Jun-01	BA1-117-(6/7)-U	BA-01-00225		12
31	126	8	25	6/7	26-Jun-01	BA1-126-(6/7)-U	BA-01-00224		5.4
32	112	9	50	6/7	26-Jun-01	BA1-112-(6/7)-U	BA-01-00200		35
33	113	9	50	6/7	26-Jun-01	BA1-113-(6/7)-U	BA-01-00191		19
34	135	9	50	6/7	26-Jun-01	BA1-135-(6/7)-U	BA-01-00196		18
35	154	9	50	6/7	26-Jun-01	BA1-154-(6/7)-U	BA-01-00230		67
36	124	10	75	6/7	26-Jun-01	BA1-124-(6/7)-U	BA-01-00207		96
37	133	10	75	6/7	26-Jun-01	BA1-133-(6/7)-U	BA-01-00235		60
38	158	10	75	6/7	26-Jun-01	BA1-158-(6/7)-U	BA-01-00199		140
39	160	10	75	6/7	26-Jun-01	BA1-160-(6/7)-U	BA-01-00218		69
40	2108	1	0	6/7	26-Jun-01	BA1-2108-(6/7)-U	BA-01-00211		2
41	2125	7	75	6/7	26-Jun-01	BA1-2125-(6/7)-U	BA-01-00231		23
42	2115	3	50	6/7	26-Jun-01	BA1-2115-(6/7)-U	BA-01-00185		29
43	AsCtrl			6/7	26-Jun-01	BA1-AsCtrl-(6/7)-U	BA-01-00194		3
44	AsIA500			6/7	26-Jun-01	BA1-AsIA500-(6/7)-U	BA-01-00229		520
45	AsIB500			6/7	26-Jun-01	BA1-AsIB500-(6/7)-U	BA-01-00214		500
46	AsOA500			6/7	26-Jun-01	BA1-AsOA500-(6/7)-U	BA-01-00226		510
47	AsOB500			6/7	26-Jun-01	BA1-AsOB500-(6/7)-U	BA-01-00227		510
48	AsIA100			6/7	26-Jun-01	BA1-AsIA100-(6/7)-U	BA-01-00206		100
49	AsIB100			6/7	26-Jun-01	BA1-AsIB100-(6/7)-U	BA-01-00221		100
50	AsOA100			6/7	26-Jun-01	BA1-AsOA100-(6/7)-U	BA-01-00237		100
51	AsOB100			6/7	26-Jun-01	BA1-AsOB100-(6/7)-U	BA-01-00228		100
52	AsIA25			6/7	26-Jun-01	BA1-AsIA25-(6/7)-U	BA-01-00212		28
53	AsIB25			6/7	26-Jun-01	BA1-AsIB25-(6/7)-U	BA-01-00223		27

TABLE A-7 URINE ANALYTICAL RESULTS

ID	pig number	group	dosage	day	date collected	sample number	tag number2	MgNO3 Q	MgNO3 ng/mL
54	AsOA25			6/7	26-Jun-01	BA1-AsOA25-(6/7)-U	BA-01-00202		28
55	AsOB25			6/7	26-Jun-01	BA1-AsOB25-(6/7)-U	BA-01-00193		28
56	108	1	0	8/9	28-Jun-01	BA1-108-(8/9)-U	BA-01-00288		2
57	145	1	0	8/9	28-Jun-01	BA1-145-(8/9)-U	BA-01-00281		3
58	157	1	0	8/9	28-Jun-01	BA1-157-(8/9)-U	BA-01-00265		2
59	122	2	25	8/9	28-Jun-01	BA1-122-(8/9)-U	BA-01-00243		82
60	123	2	25	8/9	28-Jun-01	BA1-123-(8/9)-U	BA-01-00273		18
61	147	2	25	8/9	28-Jun-01	BA1-147-(8/9)-U	BA-01-00291		51
62	156	2	25	8/9	28-Jun-01	BA1-156-(8/9)-U	BA-01-00269		80
63	101	3	50	8/9	28-Jun-01	BA1-101-(8/9)-U	BA-01-00245		31
64	115	3	50	8/9	28-Jun-01	BA1-115-(8/9)-U	BA-01-00257		37
65	119	3	50	8/9	28-Jun-01	BA1-119-(8/9)-U	BA-01-00282		270
66	151	3	50	8/9	28-Jun-01	BA1-151-(8/9)-U	BA-01-00289		230
67	121	4	75	8/9	28-Jun-01	BA1-121-(8/9)-U	BA-01-00292		130
68	136	4	75	8/9	28-Jun-01	BA1-136-(8/9)-U	BA-01-00261		110
69	140	4	75	8/9	28-Jun-01	BA1-140-(8/9)-U	BA-01-00253		140
70	148	4	75	8/9	28-Jun-01	BA1-148-(8/9)-U	BA-01-00247		130
71	104	5	25	8/9	28-Jun-01	BA1-104-(8/9)-U	BA-01-00244		17
72	106	5	25	8/9	28-Jun-01	BA1-106-(8/9)-U	BA-01-00251		16
73	128	5	25	8/9	28-Jun-01	BA1-128-(8/9)-U	BA-01-00240		14
74	155	5	25	8/9	28-Jun-01	BA1-155-(8/9)-U	BA-01-00250		17
75	103	6	50	8/9	28-Jun-01	BA1-103-(8/9)-U	BA-01-00252		19
76	110	6	50	8/9	28-Jun-01	BA1-110-(8/9)-U	BA-01-00239		28
77	116	6	50	8/9	28-Jun-01	BA1-116-(8/9)-U	BA-01-00256		15
78	142	6	50	8/9	28-Jun-01	BA1-142-(8/9)-U	BA-01-00290		27
79	120	7	75	8/9	28-Jun-01	BA1-120-(8/9)-U	BA-01-00276		missing
80	125	7	75	8/9	28-Jun-01	BA1-125-(8/9)-U	BA-01-00258		19
81	138	7	75	8/9	28-Jun-01	BA1-138-(8/9)-U	BA-01-00268		84
82	150	7	75	8/9	28-Jun-01	BA1-150-(8/9)-U	BA-01-00286		34
83	102	8	25	8/9	28-Jun-01	BA1-102-(8/9)-U	BA-01-00293		15
84	114	8	25	8/9	28-Jun-01	BA1-114-(8/9)-U	BA-01-00241		15
85	117	8	25	8/9	28-Jun-01	BA1-117-(8/9)-U	BA-01-00242		12
86	126	8	25	8/9	28-Jun-01	BA1-126-(8/9)-U	BA-01-00272		6.5
87	112	9	50	8/9	28-Jun-01	BA1-112-(8/9)-U	BA-01-00262		25
88	113	9	50	8/9	28-Jun-01	BA1-113-(8/9)-U	BA-01-00267		18
89	135	9	50	8/9	28-Jun-01	BA1-135-(8/9)-U	BA-01-00277		37
90	154	9	50	8/9	28-Jun-01	BA1-154-(8/9)-U	BA-01-00287		28
91	124	10	75	8/9	28-Jun-01	BA1-124-(8/9)-U	BA-01-00271		80
92	133	10	75	8/9	28-Jun-01	BA1-133-(8/9)-U	BA-01-00283		58
93	158	10	75	8/9	28-Jun-01	BA1-158-(8/9)-U	BA-01-00259		62
94	160	10	75	8/9	28-Jun-01	BA1-160-(8/9)-U	BA-01-00270		57
95	2135	9	50	8/9	28-Jun-01	BA1-2135-(8/9)-U	BA-01-00249		35
96	2103	6	50	8/9	28-Jun-01	BA1-2103-(8/9)-U	BA-01-00248		17
97	2157	1	0	8/9	28-Jun-01	BA1-2157-(8/9)-U	BA-01-00274		2
98	AsCtrl			8/9	28-Jun-01	BA1-AsCtrl-(8/9)-U	BA-01-00280		3
99	AsIA500			8/9	28-Jun-01	BA1-AsIA500-(8/9)-U	BA-01-00284		560
100	AsIB500			8/9	28-Jun-01	BA1-AsIB500-(8/9)-U	BA-01-00254		460
101	AsOA500			8/9	28-Jun-01	BA1-AsOA500-(8/9)-U	BA-01-00278		510
102	AsOB500			8/9	28-Jun-01	BA1-AsOB500-(8/9)-U	BA-01-00279		480
103	AsIA100			8/9	28-Jun-01	BA1-AsIA100-(8/9)-U	BA-01-00266		100
104	AsIB100			8/9	28-Jun-01	BA1-AsIB100-(8/9)-U	BA-01-00285		110
105	AsOA100			8/9	28-Jun-01	BA1-AsOA100-(8/9)-U	BA-01-00255		98
106	AsOB100			8/9	28-Jun-01	BA1-AsOB100-(8/9)-U	BA-01-00260		99

TABLE A-7 URINE ANALYTICAL RESULTS

ID	pig number	group	dosage	day	date collected	sample number	tag number2	MgNO3 Q	MgNO3 ng/mL
107	AsIA25			8/9	28-Jun-01	BA1-AsIA25-(8/9)-U	BA-01-00264		28
108	AsIB25			8/9	28-Jun-01	BA1-AsIB25-(8/9)-U	BA-01-00246		27
109	AsOA25			8/9	28-Jun-01	BA1-AsOA25-(8/9)-U	BA-01-00275		28
110	AsOB25			8/9	28-Jun-01	BA1-AsOB25-(8/9)-U	BA-01-00263		26
111	108	1	0	10/11	30-Jun-01	BA1-108-(10/11)-U	BA-01-00326		1.8
112	145	1	0	10/11	30-Jun-01	BA1-145-(10/11)-U	BA-01-00314		2
113	157	1	0	10/11	30-Jun-01	BA1-157-(10/11)-U	BA-01-00297		2
114	122	2	25	10/11	30-Jun-01	BA1-122-(10/11)-U	BA-01-00300		89
115	123	2	25	10/11	30-Jun-01	BA1-123-(10/11)-U	BA-01-00328		20
116	147	2	25	10/11	30-Jun-01	BA1-147-(10/11)-U	BA-01-00334		80
117	156	2	25	10/11	30-Jun-01	BA1-156-(10/11)-U	BA-01-00309		87
118	101	3	50	10/11	30-Jun-01	BA1-101-(10/11)-U	BA-01-00335		21
119	115	3	50	10/11	30-Jun-01	BA1-115-(10/11)-U	BA-01-00304		36
120	119	3	50	10/11	30-Jun-01	BA1-119-(10/11)-U	BA-01-00332		400
121	151	3	50	10/11	30-Jun-01	BA1-151-(10/11)-U	BA-01-00305		190
122	121	4	75	10/11	30-Jun-01	BA1-121-(10/11)-U	BA-01-00322		140
123	136	4	75	10/11	30-Jun-01	BA1-136-(10/11)-U	BA-01-00321		120
124	140	4	75	10/11	30-Jun-01	BA1-140-(10/11)-U	BA-01-00306		110
125	148	4	75	10/11	30-Jun-01	BA1-148-(10/11)-U	BA-01-00311		140
126	104	5	25	10/11	30-Jun-01	BA1-104-(10/11)-U	BA-01-00316		19
127	106	5	25	10/11	30-Jun-01	BA1-106-(10/11)-U	BA-01-00303		23
128	128	5	25	10/11	30-Jun-01	BA1-128-(10/11)-U	BA-01-00294		missing
129	155	5	25	10/11	30-Jun-01	BA1-155-(10/11)-U	BA-01-00313		20
130	103	6	50	10/11	30-Jun-01	BA1-103-(10/11)-U	BA-01-00301		21
131	110	6	50	10/11	30-Jun-01	BA1-110-(10/11)-U	BA-01-00318		32
132	116	6	50	10/11	30-Jun-01	BA1-116-(10/11)-U	BA-01-00329		17
133	142	6	50	10/11	30-Jun-01	BA1-142-(10/11)-U	BA-01-00298		35
134	120	7	75	10/11	30-Jun-01	BA1-120-(10/11)-U	BA-01-00330		45
135	125	7	75	10/11	30-Jun-01	BA1-125-(10/11)-U	BA-01-00308		15
136	138	7	75	10/11	30-Jun-01	BA1-138-(10/11)-U	BA-01-00315		120
137	150	7	75	10/11	30-Jun-01	BA1-150-(10/11)-U	BA-01-00319		23
138	102	8	25	10/11	30-Jun-01	BA1-102-(10/11)-U	BA-01-00320		16
139	114	8	25	10/11	30-Jun-01	BA1-114-(10/11)-U	BA-01-00317		19
140	117	8	25	10/11	30-Jun-01	BA1-117-(10/11)-U	BA-01-00302		7.7
141	126	8	25	10/11	30-Jun-01	BA1-126-(10/11)-U	BA-01-00333		5.4
142	112	9	50	10/11	30-Jun-01	BA1-112-(10/11)-U	BA-01-00325		25
143	113	9	50	10/11	30-Jun-01	BA1-113-(10/11)-U	BA-01-00323		19
144	135	9	50	10/11	30-Jun-01	BA1-135-(10/11)-U	BA-01-00324		5.9
145	154	9	50	10/11	30-Jun-01	BA1-154-(10/11)-U	BA-01-00299		40
146	124	10	75	10/11	30-Jun-01	BA1-124-(10/11)-U	BA-01-00312		33
147	133	10	75	10/11	30-Jun-01	BA1-133-(10/11)-U	BA-01-00296		49
148	158	10	75	10/11	30-Jun-01	BA1-158-(10/11)-U	BA-01-00327		96
149	160	10	75	10/11	30-Jun-01	BA1-160-(10/11)-U	BA-01-00295		47
150	2145	1	0	10/11	30-Jun-01	BA1-2145-(10/11)-U	BA-01-00310		1
151	2133	10	75	10/11	30-Jun-01	BA1-2133-(10/11)-U	BA-01-00307		48
152	2148	4	75	10/11	30-Jun-01	BA1-2148-(10/11)-U	BA-01-00336		140
153	AsCtrl			10/11	30-Jun-01	BA1-AsCtrl-(10/11)-U	BA-01-00331		3

TABLE A-8 FECES ANALYTICAL RESULTS

ID	pig number	group	dosage	day	date collected	sample number	tag number	Q	Conc
1	108	1	0	6/7	26-Jun-01	BA1-108-(6/7)-P	BA-01-00346		30
2	145	1	0	6/7	26-Jun-01	BA1-145-(6/7)-P	BA-01-00348		10
3	157	1	0	6/7	26-Jun-01	BA1-157-(6/7)-P	BA-01-00372		10
4	122	2	25	6/7	26-Jun-01	BA1-122-(6/7)-P	BA-01-00362		73
5	123	2	25	6/7	26-Jun-01	BA1-123-(6/7)-P	BA-01-00383		190
6	147	2	25	6/7	26-Jun-01	BA1-147-(6/7)-P	BA-01-00388		240
7	156	2	25	6/7	26-Jun-01	BA1-156-(6/7)-P	BA-01-00341		540
8	101	3	50	6/7	26-Jun-01	BA1-101-(6/7)-P	BA-01-00364		130
9	115	3	50	6/7	26-Jun-01	BA1-115-(6/7)-P	BA-01-00338		460
10	119	3	50	6/7	26-Jun-01	BA1-119-(6/7)-P	BA-01-00350		2880
11	151	3	50	6/7	26-Jun-01	BA1-151-(6/7)-P	BA-01-00355		210
12	121	4	75	6/7	26-Jun-01	BA1-121-(6/7)-P	BA-01-00387		310
13	136	4	75	6/7	26-Jun-01	BA1-136-(6/7)-P	BA-01-00389		510
14	140	4	75	6/7	26-Jun-01	BA1-140-(6/7)-P	BA-01-00384		1400
15	148	4	75	6/7	26-Jun-01	BA1-148-(6/7)-P	BA-01-00385		750
16	104	5	25	6/7	26-Jun-01	BA1-104-(6/7)-P	BA-01-00353		1400
17	106	5	25	6/7	26-Jun-01	BA1-106-(6/7)-P	BA-01-00386		900
18	128	5	25	6/7	26-Jun-01	BA1-128-(6/7)-P	BA-01-00381		1000
19	155	5	25	6/7	26-Jun-01	BA1-155-(6/7)-P	BA-01-00375		1100
20	103	6	50	6/7	26-Jun-01	BA1-103-(6/7)-P	BA-01-00347		2600
21	110	6	50	6/7	26-Jun-01	BA1-110-(6/7)-P	BA-01-00390		1500
22	116	6	50	6/7	26-Jun-01	BA1-116-(6/7)-P	BA-01-00366		3400
23	142	6	50	6/7	26-Jun-01	BA1-142-(6/7)-P	BA-01-00342		3800
24	120	7	75	6/7	26-Jun-01	BA1-120-(6/7)-P	BA-01-00376		2000
25	125	7	75	6/7	26-Jun-01	BA1-125-(6/7)-P	BA-01-00343		3400
26	138	7	75	6/7	26-Jun-01	BA1-138-(6/7)-P	BA-01-00365		5600
27	150	7	75	6/7	26-Jun-01	BA1-150-(6/7)-P	BA-01-00351		2700
28	102	8	25	6/7	26-Jun-01	BA1-102-(6/7)-P	BA-01-00358		630
29	114	8	25	6/7	26-Jun-01	BA1-114-(6/7)-P	BA-01-00367		640
30	117	8	25	6/7	26-Jun-01	BA1-117-(6/7)-P	BA-01-00356		1200
31	126	8	25	6/7	26-Jun-01	BA1-126-(6/7)-P	BA-01-00373		1200
32	112	9	50	6/7	26-Jun-01	BA1-112-(6/7)-P	BA-01-00357		2400
33	113	9	50	6/7	26-Jun-01	BA1-113-(6/7)-P	BA-01-00349		2700
34	135	9	50	6/7	26-Jun-01	BA1-135-(6/7)-P	BA-01-00363		2200
35	154	9	50	6/7	26-Jun-01	BA1-154-(6/7)-P	BA-01-00371		3100
36	124	10	75	6/7	26-Jun-01	BA1-124-(6/7)-P	BA-01-00352		3700
37	133	10	75	6/7	26-Jun-01	BA1-133-(6/7)-P	BA-01-00374		4800
38	158	10	75	6/7	26-Jun-01	BA1-158-(6/7)-P	BA-01-00344		4000
39	160	10	75	6/7	26-Jun-01	BA1-160-(6/7)-P	BA-01-00339		1100
40	2142	6	50	6/7	26-Jun-01	BA1-2142-(6/7)-P	BA-01-00354		3700
41	2148	4	75	6/7	26-Jun-01	BA1-2148-(6/7)-P	BA-01-00340		700
42	2110	6	50	6/7	26-Jun-01	BA1-2110-(6/7)-P	BA-01-00361		1900
43	FAsCtrl			6/7	26-Jun-01	BA1-FAsCtrl-(6/7)-P	BA-01-00370		48
44	FAsIAHigh			6/7	26-Jun-01	BA1-FAsIAHigh-(6/7)-P	BA-01-00379		3500
45	FAsIBHigh			6/7	26-Jun-01	BA1-FAsIBHigh-(6/7)-P	BA-01-00359		3200
46	FAsOAHigh			6/7	26-Jun-01	BA1-FAsOAHigh-(6/7)-P	BA-01-00378		3500
47	FAsOBHigh			6/7	26-Jun-01	BA1-FAsOBHigh-(6/7)-P	BA-01-00337		2300
48	FAsIAMed			6/7	26-Jun-01	BA1-FAsIAMed-(6/7)-P	BA-01-00368		1800
49	FAsIBMed			6/7	26-Jun-01	BA1-FAsIBMed-(6/7)-P	BA-01-00345		1600
50	FAsOAMed			6/7	26-Jun-01	BA1-FAsOAMed-(6/7)-P	BA-01-00380		1800
51	FAsOBMed			6/7	26-Jun-01	BA1-FAsOBMed-(6/7)-P	BA-01-00369		1800
52	FAsIALow			6/7	26-Jun-01	BA1-FAsIALow-(6/7)-P	BA-01-00391		470
53	FAsIBLow			6/7	26-Jun-01	BA1-FAsIBLow-(6/7)-P	BA-01-00360		430
54	FAsOALow			6/7	26-Jun-01	BA1-FAsOALow-(6/7)-P	BA-01-00382		missing

TABLE A-8 FECES ANALYTICAL RESULTS

ID	pig number	group	dosage	day	date collected	sample number	tag number	Q	Conc
55	FAsOBLow			6/7	26-Jun-01	BA1-FAsOBLow-(6/7)-P	BA-01-00377		330
56	108	1	0	8/9	28-Jun-01	BA1-108-(8/9)-P	BA-01-00446		81
57	145	1	0	8/9	28-Jun-01	BA1-145-(8/9)-P	BA-01-00395		10
58	157	1	0	8/9	28-Jun-01	BA1-157-(8/9)-P	BA-01-00431		20
59	122	2	25	8/9	28-Jun-01	BA1-122-(8/9)-P	BA-01-00422		59
60	123	2	25	8/9	28-Jun-01	BA1-123-(8/9)-P	BA-01-00425		160
61	147	2	25	8/9	28-Jun-01	BA1-147-(8/9)-P	BA-01-00404		300
62	156	2	25	8/9	28-Jun-01	BA1-156-(8/9)-P	BA-01-00415		75
63	101	3	50	8/9	28-Jun-01	BA1-101-(8/9)-P	BA-01-00413		76
64	115	3	50	8/9	28-Jun-01	BA1-115-(8/9)-P	BA-01-00407		170
65	119	3	50	8/9	28-Jun-01	BA1-119-(8/9)-P	BA-01-00445		150
66	151	3	50	8/9	28-Jun-01	BA1-151-(8/9)-P	BA-01-00440		250
67	121	4	75	8/9	28-Jun-01	BA1-121-(8/9)-P	BA-01-00434		250
68	136	4	75	8/9	28-Jun-01	BA1-136-(8/9)-P	BA-01-00409		340
69	140	4	75	8/9	28-Jun-01	BA1-140-(8/9)-P	BA-01-00442		1200
70	148	4	75	8/9	28-Jun-01	BA1-148-(8/9)-P	BA-01-00443		320
71	104	5	25	8/9	28-Jun-01	BA1-104-(8/9)-P	BA-01-00399		1500
72	106	5	25	8/9	28-Jun-01	BA1-106-(8/9)-P	BA-01-00444		800
73	128	5	25	8/9	28-Jun-01	BA1-128-(8/9)-P	BA-01-00414		240
74	155	5	25	8/9	28-Jun-01	BA1-155-(8/9)-P	BA-01-00427		490
75	103	6	50	8/9	28-Jun-01	BA1-103-(8/9)-P	BA-01-00428		2600
76	110	6	50	8/9	28-Jun-01	BA1-110-(8/9)-P	BA-01-00432		2500
77	116	6	50	8/9	28-Jun-01	BA1-116-(8/9)-P	BA-01-00403		2300
78	142	6	50	8/9	28-Jun-01	BA1-142-(8/9)-P	BA-01-00437		3000
79	120	7	75	8/9	28-Jun-01	BA1-120-(8/9)-P	BA-01-00420		3300
80	125	7	75	8/9	28-Jun-01	BA1-125-(8/9)-P	BA-01-00405		2700
81	138	7	75	8/9	28-Jun-01	BA1-138-(8/9)-P	BA-01-00417		3000
82	150	7	75	8/9	28-Jun-01	BA1-150-(8/9)-P	BA-01-00394		1900
83	102	8	25	8/9	28-Jun-01	BA1-102-(8/9)-P	BA-01-00397		980
84	114	8	25	8/9	28-Jun-01	BA1-114-(8/9)-P	BA-01-00396		900
85	117	8	25	8/9	28-Jun-01	BA1-117-(8/9)-P	BA-01-00392		1200
86	126	8	25	8/9	28-Jun-01	BA1-126-(8/9)-P	BA-01-00419		1200
87	112	9	50	8/9	28-Jun-01	BA1-112-(8/9)-P	BA-01-00421		2800
88	113	9	50	8/9	28-Jun-01	BA1-113-(8/9)-P	BA-01-00402		770
89	135	9	50	8/9	28-Jun-01	BA1-135-(8/9)-P	BA-01-00438		2100
90	154	9	50	8/9	28-Jun-01	BA1-154-(8/9)-P	BA-01-00430		1700
91	124	10	75	8/9	28-Jun-01	BA1-124-(8/9)-P	BA-01-00406		2800
92	133	10	75	8/9	28-Jun-01	BA1-133-(8/9)-P	BA-01-00401		2900
93	158	10	75	8/9	28-Jun-01	BA1-158-(8/9)-P	BA-01-00439		3500
94	160	10	75	8/9	28-Jun-01	BA1-160-(8/9)-P	BA-01-00441		3600
95	2104	5	25	8/9	28-Jun-01	BA1-2104-(8/9)-P	BA-01-00429		1600
96	2136	4	75	8/9	28-Jun-01	BA1-2136-(8/9)-P	BA-01-00424		300
97	2148	4	75	8/9	28-Jun-01	BA1-2148-(8/9)-P	BA-01-00408		340
98	FAsCtrl			8/9	28-Jun-01	BA1-FAsCtrl-(8/9)-P	BA-01-00412		29
99	FAsIAHigh			8/9	28-Jun-01	BA1-FAsIAHigh-(8/9)-P	BA-01-00435		3600
100	FAsIBHigh			8/9	28-Jun-01	BA1-FAsIBHigh-(8/9)-P	BA-01-00398		3300
101	FAsOAHigh			8/9	28-Jun-01	BA1-FAsOAHigh-(8/9)-P	BA-01-00416		3400
102	FAsOBHigh			8/9	28-Jun-01	BA1-FAsOBHigh-(8/9)-P	BA-01-00410		2400
103	FAsIAMed			8/9	28-Jun-01	BA1-FAsIAMed-(8/9)-P	BA-01-00418		1800
104	FAsIBMed			8/9	28-Jun-01	BA1-FAsIBMed-(8/9)-P	BA-01-00436		1700
105	FAsOAMed			8/9	28-Jun-01	BA1-FAsOAMed-(8/9)-P	BA-01-00393		1800
106	FAsOBMed			8/9	28-Jun-01	BA1-FAsOBMed-(8/9)-P	BA-01-00400		1700
107	FAsIALow			8/9	28-Jun-01	BA1-FAsIALow-(8/9)-P	BA-01-00426		450
108	FAsIBLow			8/9	28-Jun-01	BA1-FAsIBLow-(8/9)-P	BA-01-00411		450

TABLE A-8 FECES ANALYTICAL RESULTS

ID	pig number	group	dosage	day	date collected	sample number	tag number	Q	Conc
109	FAsOALow			8/9	28-Jun-01	BA1-FAsOALow-(8/9)-P	BA-01-00423		missing
110	FAsOBLow			8/9	28-Jun-01	BA1-FAsOBLow-(8/9)-P	BA-01-00433		380
111	108	1	0	10/11	30-Jun-01	BA1-108-(10/11)-P	BA-01-00479		99
112	145	1	0	10/11	30-Jun-01	BA1-145-(10/11)-P	BA-01-00456	<	10
113	157	1	0	10/11	30-Jun-01	BA1-157-(10/11)-P	BA-01-00461		10
114	122	2	25	10/11	30-Jun-01	BA1-122-(10/11)-P	BA-01-00463		110
115	123	2	25	10/11	30-Jun-01	BA1-123-(10/11)-P	BA-01-00452		100
116	147	2	25	10/11	30-Jun-01	BA1-147-(10/11)-P	BA-01-00448		340
117	156	2	25	10/11	30-Jun-01	BA1-156-(10/11)-P	BA-01-00451		280
118	101	3	50	10/11	30-Jun-01	BA1-101-(10/11)-P	BA-01-00454		85
119	115	3	50	10/11	30-Jun-01	BA1-115-(10/11)-P	BA-01-00458		89
120	119	3	50	10/11	30-Jun-01	BA1-119-(10/11)-P	BA-01-00449		140
121	151	3	50	10/11	30-Jun-01	BA1-151-(10/11)-P	BA-01-00484		220
122	121	4	75	10/11	30-Jun-01	BA1-121-(10/11)-P	BA-01-00457		92
123	136	4	75	10/11	30-Jun-01	BA1-136-(10/11)-P	BA-01-00453		160
124	140	4	75	10/11	30-Jun-01	BA1-140-(10/11)-P	BA-01-00460		330
125	148	4	75	10/11	30-Jun-01	BA1-148-(10/11)-P	BA-01-00477		360
126	104	5	25	10/11	30-Jun-01	BA1-104-(10/11)-P	BA-01-00450		650
127	106	5	25	10/11	30-Jun-01	BA1-106-(10/11)-P	BA-01-00467		640
128	128	5	25	10/11	30-Jun-01	BA1-128-(10/11)-P	BA-01-00476		200
129	155	5	25	10/11	30-Jun-01	BA1-155-(10/11)-P	BA-01-00483		880
130	103	6	50	10/11	30-Jun-01	BA1-103-(10/11)-P	BA-01-00485		1500
131	110	6	50	10/11	30-Jun-01	BA1-110-(10/11)-P	BA-01-00482		1300
132	116	6	50	10/11	30-Jun-01	BA1-116-(10/11)-P	BA-01-00468		2400
133	142	6	50	10/11	30-Jun-01	BA1-142-(10/11)-P	BA-01-00466		1900
134	120	7	75	10/11	30-Jun-01	BA1-120-(10/11)-P	BA-01-00474		2700
135	125	7	75	10/11	30-Jun-01	BA1-125-(10/11)-P	BA-01-00481		2400
136	138	7	75	10/11	30-Jun-01	BA1-138-(10/11)-P	BA-01-00480		5200
137	150	7	75	10/11	30-Jun-01	BA1-150-(10/11)-P	BA-01-00489		1700
138	102	8	25	10/11	30-Jun-01	BA1-102-(10/11)-P	BA-01-00473		930
139	114	8	25	10/11	30-Jun-01	BA1-114-(10/11)-P	BA-01-00488		1000
140	117	8	25	10/11	30-Jun-01	BA1-117-(10/11)-P	BA-01-00465		1400
141	126	8	25	10/11	30-Jun-01	BA1-126-(10/11)-P	BA-01-00469		1200
142	112	9	50	10/11	30-Jun-01	BA1-112-(10/11)-P	BA-01-00472		1600
143	113	9	50	10/11	30-Jun-01	BA1-113-(10/11)-P	BA-01-00471		1600
144	135	9	50	10/11	30-Jun-01	BA1-135-(10/11)-P	BA-01-00470		1400
145	154	9	50	10/11	30-Jun-01	BA1-154-(10/11)-P	BA-01-00487		4200
146	124	10	75	10/11	30-Jun-01	BA1-124-(10/11)-P	BA-01-00478		2800
147	133	10	75	10/11	30-Jun-01	BA1-133-(10/11)-P	BA-01-00447		2500
148	158	10	75	10/11	30-Jun-01	BA1-158-(10/11)-P	BA-01-00464		2300
149	160	10	75	10/11	30-Jun-01	BA1-160-(10/11)-P	BA-01-00455		2700
150	2101	3	50	10/11	30-Jun-01	BA1-2101-(10/11)-P	BA-01-00486		92
151	2114	8	25	10/11	30-Jun-01	BA1-2114-(10/11)-P	BA-01-00462		1000
152	2125	7	75	10/11	30-Jun-01	BA1-2125-(10/11)-P	BA-01-00459		2300
153	FAsCtrl			10/11	30-Jun-01	BA1-FAsCtrl-(10/11)-P	BA-01-00475		40

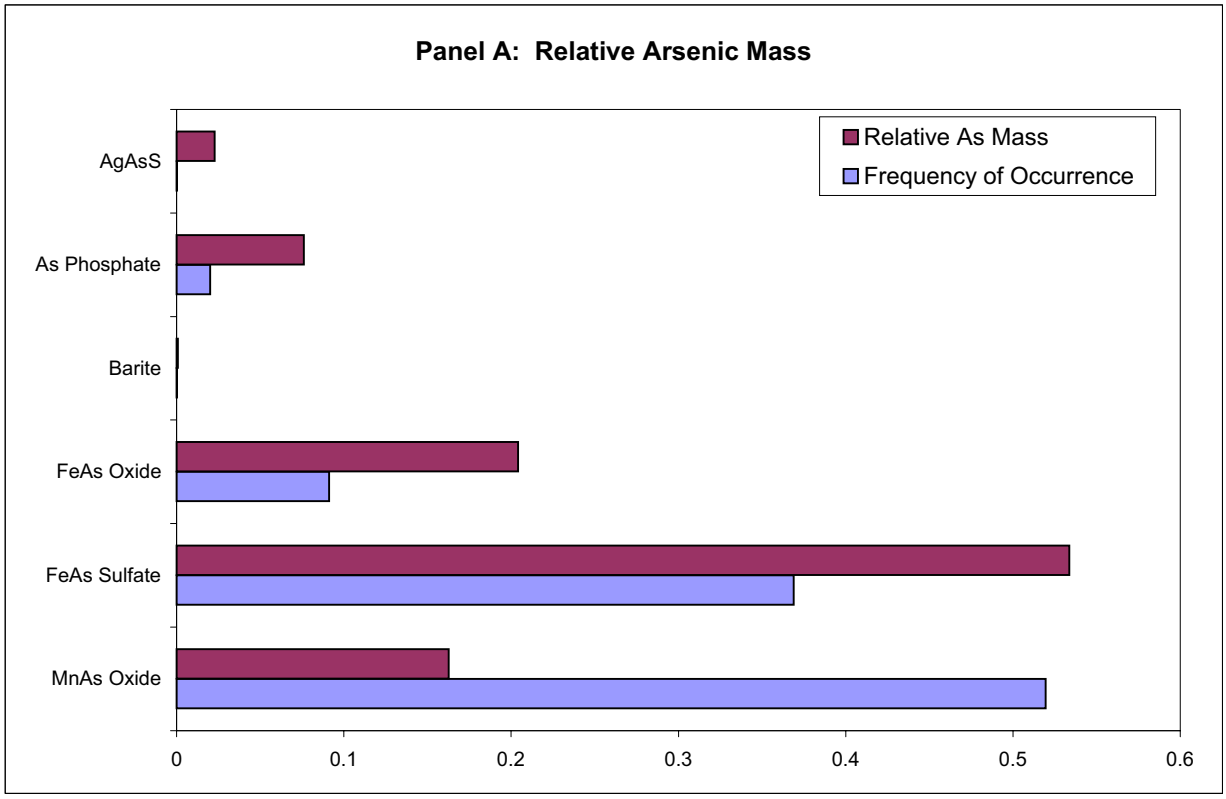
APPENDIX B

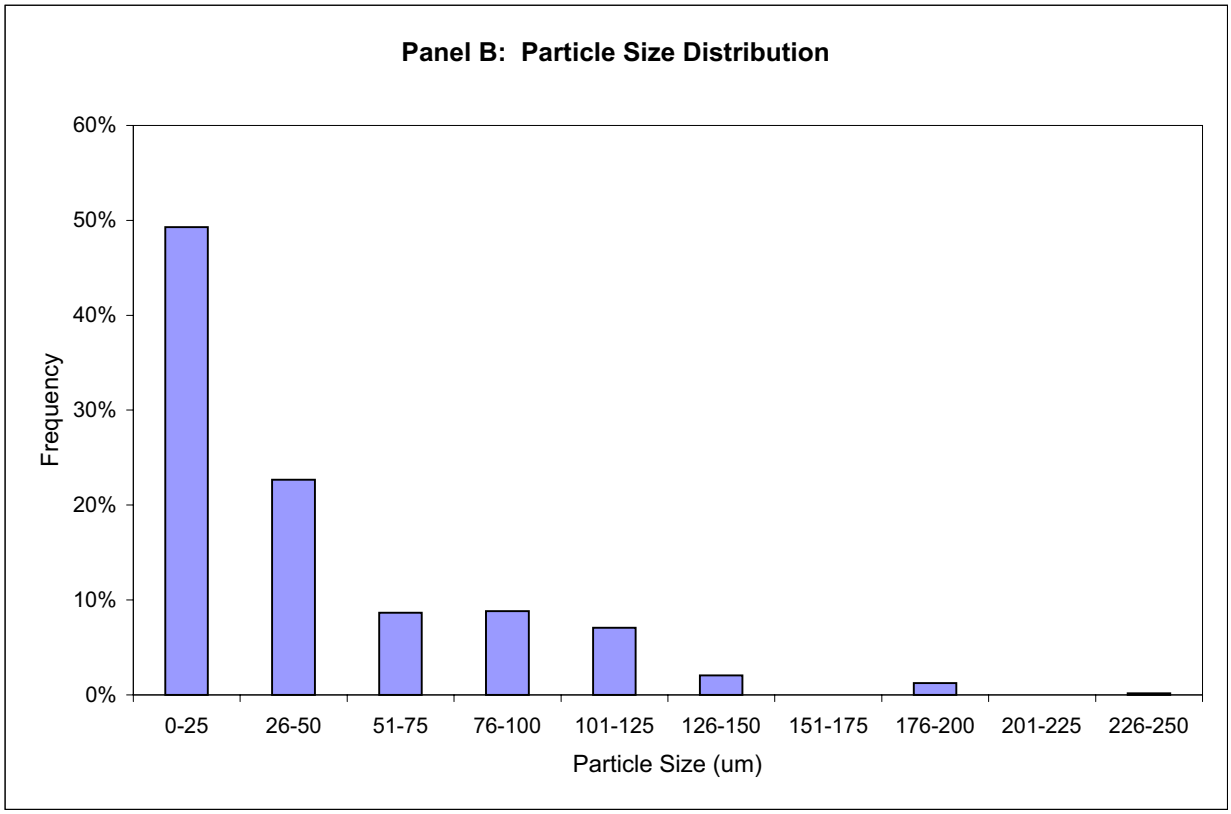
DETAILED ARSENIC SPECIATION RESULTS

Butte Test Material 1 - Arsenic Speciation Summary Statistics

Phase	Count		Count Frequency (%)		Size			Size Frequency (%)		Relative Arsenic Mass (%)	
	Total	Lib	Total	Lib	Total	Lib	Mean	Total	Lib	Total	Liberated
AgAsS	1	1	0.2%	0.2%	7	7	7	0.02%	0.02%	2.27%	2.27%
FeAs Oxide	22	22	3.5%	3.8%	775	775	35	2.34%	2.34%	9.95%	9.95%
FeAs Oxide	37	27	5.8%	4.6%	2242	1770	61	6.77%	5.35%	10.47%	8.26%
MnAs Oxide	79	79	12.4%	13.5%	10193	10193	129	30.78%	30.78%	11.15%	11.15%
MnAs Oxide	161	150	25.3%	25.6%	7009	6264	44	21.17%	18.92%	5.11%	4.57%
As Phosphate	4	4	0.6%	0.7%	18	18	5	0.05%	0.05%	0.05%	0.05%
As Phosphate	12	1	1.9%	0.2%	647	12	54	1.95%	0.04%	7.55%	0.14%
FeAs Sulfate	74	74	11.6%	12.6%	2889	2889	39	8.72%	8.72%	15.60%	15.60%
FeAs Sulfate	245	226	38.5%	38.6%	9327	8673	38	28.17%	26.19%	37.76%	35.12%
Barite	1	1	0.2%	0.2%	5	5	5	0.02%	0.02%	0.07%	0.07%
	636	585	100.0%	100.0%	33112	30606		100.00%	92.43%	100.00%	87.19%

BUTTE TEST MATERIAL 1 - SPECIATION AND PARTICLE SIZE DATA





Butte Test Material 2 - Arsenic Speciation Summary Statistics

Phase	Count		Count Frequency (%)		Size			Size Frequency (%)		Relative Arsenic Mass (%)	
	Total	Lib	Total	Lib	Total	Lib	Mean	Total	Lib	Total	Liberated
Clays	1	1	0.7%	0.7%	90	90	90	2.01%	2.01%	0.07%	0.07%
AsMSO4	1	1	0.7%	0.7%	8	8	8	0.18%	0.18%	0.33%	0.33%
FeAs Oxide	75	75	54.7%	54.7%	2770	2770	37	61.97%	61.97%	39.28%	39.28%
Pyrite	7	7	5.1%	5.1%	139	139	20	3.11%	3.11%	0.13%	0.13%
Slag	1	1	0.7%	0.7%	85	85	85	1.90%	1.90%	0.04%	0.04%
Sulfosalts	20	20	14.6%	14.6%	150	150	8	3.36%	3.36%	41.87%	41.87%
FeAs Sulfate	32	32	23.4%	23.4%	1228	1228	38	27.47%	27.47%	18.28%	18.28%
	137	137	100.0%	100.0%	4470	4470		100.00%	100.00%	100.00%	100.00%

BUTTE TEST MATERIAL 2 - SPECIATION AND PARTICLE SIZE DATA