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*science for a changing world*

Expanded Monitoring Program

Near Deer Trail, Colorado

Program Overview

Metro Wastewater Reclamation District (Metro District) applies biosolids to their properties near Deer Trail, Colorado. These biosolids applications could affect the quality of water in alluvial and bedrock aquifers, streambed sediment, soil, dust, and crops.

Water quality can be directly affected through:

- Contaminated recharge water, or
- Infiltration of water through contaminated soils or sediments (remobilization).

Water quality can be indirectly affected through:

- Tilling that mobilizes or changes subsurface chemical constituents, or
- Contributions to natural processes such as nitrification.

Contaminated groundwater or surface water could contaminate:

- Other aquifers, such as bedrock water-supply aquifers or alluvial aquifers,
- Other surface-water bodies (ponds or streams), or
- Streambed sediments.

Biosolids must meet regulatory standards, and the biosolids chemical data need to be accurate or else agronomic loading rates will be incorrect and soils could be overloaded. Soil quality could either be improved by biosolids applications through increased nutrients and organic matter, or degraded through excessive nutrients or metals.

The U.S. Geological Survey (USGS) has a monitoring program to address concerns from a stakeholder group about the biosolids and the quality of the environment in the vicinity of the biosolids-application areas. The USGS monitoring program near Deer Trail is referred to as the "USGS Expanded Monitoring Program" and began in January 1999. The first phase of monitoring ended in 2003. All data and interpretive reports from the 1999-2003 monitoring period were published by January 2005 and are available to the public. An interim monitoring period (2004 through mid-2005) continued the monitoring while reports were completed, results were presented, and a new phase of the monitoring program was negotiated for 2005-2011.



USGS

The U.S. Geological Survey is a science organization that provides the Nation with reliable, impartial information to describe and understand the Earth. The national USGS home page: <http://www.usgs.gov>

This USGS Program:

The Internet address for this program, including links for data and reports, is:

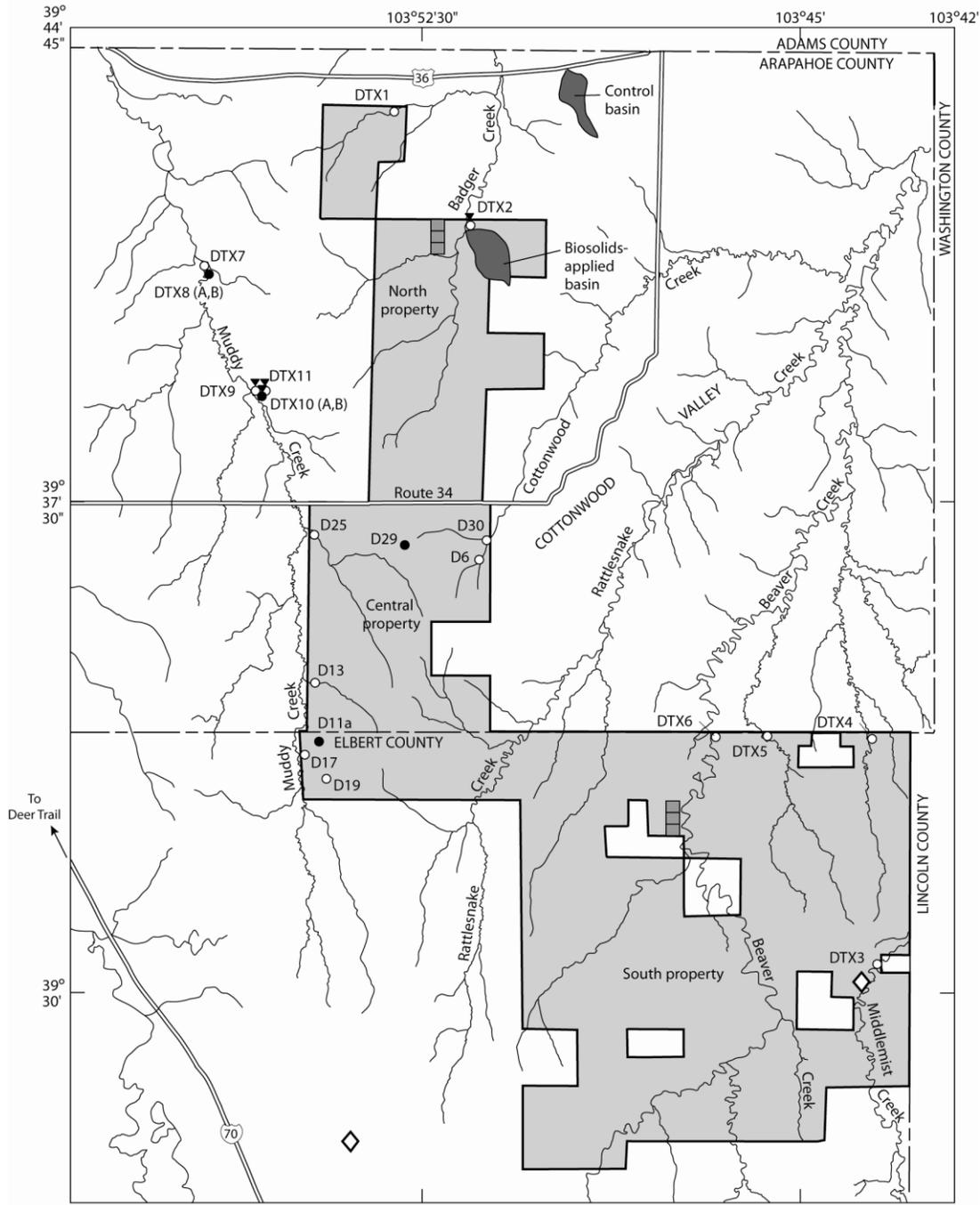
<http://co.water.usgs.gov/projects/CO406/index.html>

The address for just the continuous-recorder data is:

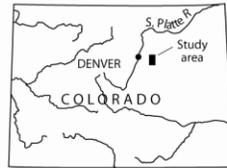
<http://co.water.usgs.gov/projects/CO406/data.html>

OR

<http://water.usgs.gov/co/nwis>



Base from U.S. Geological Survey 1:50,000 quadrangles, Elbert County and Arapahoe County



EXPLANATION

- Metro Wastewater Reclamation District property
- Streambed-sediment sampling area
- DTX1 ○ USGS alluvial-aquifer monitoring well and identifier
- D29 ● USGS bedrock-aquifer monitoring well and identifier
- DTX2 ○ Monitoring well with continuous recorder and identifier
- ◇ Dust-sampling location
- Soil-sampling area

Location of study area and U.S. Geological Survey monitoring sites near Deer Trail, Colorado, 2005-2010. (Metro Wastewater Reclamation District property boundaries shown are from 1999.)

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Each USGS monitoring program builds on the previous monitoring program. Results from the previous monitoring program are used to determine priorities for the next phase of study. The USGS Expanded Monitoring Program is distinct from, but builds on, another USGS program that monitored shallow groundwater quality on the Metro District central property from 1993–98. The newer program (1999–2011) considers environmental-quality issues for shallow and deep groundwater, surface water (streambed sediment), biosolids, soil, and crops. The expanded monitoring program includes all three Metro District properties (north, central, and south) and related private-property locations. Both programs, however, are supported by the Metro District and USGS. The first phase of the newer monitoring program also was supported by the North Kiowa Bijou Groundwater Management District in 1999. Both programs are designed, carried out, and interpreted independently by the USGS, and quality-assured USGS data and reports are released to the public and the Metro District at the same time. By definition and design, all USGS monitoring programs are independent and unbiased.

The objectives of the USGS Expanded Monitoring Program are to:

- (1) Evaluate the combined effects of biosolids applications, land use, and natural processes on alluvial aquifers, the bedrock aquifer, streambed sediment, soil, dust, and crops by comparing chemical data to
 - State or Federal regulatory limits,
 - Data from a site where biosolids are not applied (a control site), or
 - Earlier data from the same site (trends).
- (2) Monitor biosolids for chemistry, and compare the concentrations with regulatory limits.
- (3) Determine the aquifer hydrology in this area.
- (4) Develop a biosolids signature for water and soil.

The approach is unique for each component of the monitoring program. However, appropriate USGS methods and technologies will be applied to each component.

Progress reports such as this one were prepared quarterly for the first 2.5 years of the program and now are prepared approximately once each year and distributed to the stakeholders and other concerned people, as well as available to the general public on the Internet (<http://co.water.usgs.gov>). Each progress report summarizes progress from the previous period and plans for the current period; chemical data are included when available. USGS reports will document all methods and data for the monitoring program. A comprehensive USGS report is planned for completion after 2010 that includes complete statistical analyses and interpretations. In addition, the USGS will meet with the stakeholders once a year to discuss the USGS Expanded Monitoring Program results and to consider possible changes to the Expanded Monitoring Program.

Progress Last Period (January--December 2008)

The annual stakeholder meeting was held October 2, 2008, at the Metro District shop building near Deer Trail, Colo. Presentations about the USGS Expanded Monitoring Program and Pharmaceuticals in the Environment were given to the Deer Trail Conservation District Board on November 12, 2008. The USGS also participated in multi-agency discussions about organic wastewater compounds (emerging contaminants) during this period. The USGS data report that included the Expanded Monitoring Program data for 2004 through 2006 was approved.

Information for the Current Period (January--December 2009)

The USGS released the Expanded Monitoring Program data report for 2004 through 2006 (USGS DS 379). Please refer to the project web site (provided on page 1 of this Progress Report) to access this and other USGS reports at the “Publications” link. Presentations about the USGS Expanded Monitoring Program and Pharmaceuticals in the Environment were given to the Agate Conservation District Board on February 3, 2009. A presentation about the USGS work on organic wastewater compounds in biosolids was prepared and presented August 5, 2009, at a conference about compounds of emerging concern in Fort Collins, Colorado. An annual stakeholder meeting scheduled for September 23, 2009, will be attended by the USGS to provide updates on progress and findings. A USGS data report is in preparation for the 2007 through 2008 Expanded Monitoring Program data. The USGS plans to continue research on organic wastewater compounds (emerging contaminants) related to biosolids and to participate in multi-agency discussions about this topic.

Questions & Answers

Q: What is the status of USGS reports for the study area near Deer Trail?

A: Eight data reports (1999-2006 data for all monitoring components and 1999 through 2008 data for biosolids) are published and available; a ninth data report (2007 through 2008 for all monitoring components) is in preparation. An interpretive report about the effects of biosolids on soil, crops, groundwater, and streambed sediment (1999-2003) is published and available. Also published and available is an interpretive hydrogeology report that includes the structure maps done as part of the bedrock groundwater monitoring component, and the interpretive report for the dust monitoring component. Visit the website (see page 1) or contact Tracy Yager at the USGS (see page 10) to obtain copies. An interpretive water-quality report for 1993–2008 is in preparation. In addition, the USGS has presented information about these studies at various meetings and conferences.



Q: Is the USGS still monitoring near Deer Trail?

A: Yes, the USGS began a new phase of the monitoring program in May 2005 in cooperation with the Metro District. Monitoring is scheduled for 2005 through 2010.

Q: What research is the USGS doing related to organic wastewater compounds (emerging contaminants)?

A: The USGS is researching how organic wastewater compounds change in the biosolids and soil after application to dryland farms and whether these compounds move into grain crops. The USGS also worked with Colorado State University researchers to evaluate these compounds in rainfall runoff from a biosolids-applied farm field.

Groundwater

Approach

Five USGS monitoring wells installed near the Metro District property boundaries in some of the major alluvial aquifers are sampled approximately quarterly for full inorganic chemistry. These wells also were sampled in 2005 for organic wastewater compounds. One of these wells (D6) and three upgradient wells were sampled in 2005 for nitrogen isotopes. Possible nitrogen source materials such as biosolids, soil, and rock, also were analyzed in 2005 for nitrogen isotopes. Additional USGS monitoring wells in the study area also will be sampled each year when streambed-sediment samples are not available. Two USGS monitoring wells installed downgradient from the Metro District property in the bedrock aquifer are sampled annually for full inorganic chemistry. Depth to water is measured approximately monthly at about 20 of the USGS monitoring wells. At two sites, depth to groundwater, precipitation, and other related parameters are recorded hourly. Chemical data are reviewed and statistically tested for exceedance of regulatory limits and for trends. Data also are evaluated for a possible biosolids signature and for groundwater hydrology.



Progress Last Period (January--December 2008)

Depth to groundwater was measured monthly. Groundwater was sampled for routine chemistry quarterly. All the old wells from the first phase of monitoring at the METROGRO Farm were visited and evaluated. Well D30 was

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found damaged and was closed. The other USGS monitoring wells in the study area were sampled once during Fall 2008 where feasible. Groundwater data were compiled and reviewed.

Information for the Current Period (January--December 2009)

The USGS met with the Metro District to discuss status and closure plans for the now ruined or unnecessary USGS monitoring wells (installed during the first phase of monitoring at the METROGRO Farm). Closure of selected wells was done in June, and three more wells are planned for closure in the fall. Depth to groundwater will be measured approximately monthly. Groundwater at selected sites will be sampled and analyzed quarterly. Data will be compiled and reviewed. A replacement for well D30 is planned for installation in early fall.

USGS groundwater data for samples collected January through December 2008

[Data are preliminary and subject to revision. Standards from Colorado Department of Public Health and Environment, 2004, The basic standards for groundwater, 5CCR 1002-41: November 8, 2004, variously paginated. All data from filtered samples; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, value estimated by laboratory]

Well	Sample Date	Nitrate + nitrite as		Cadmium,	Chromium,	Copper,	Lead,	Mercury,	Molybdenum,	Nickel,	Selenium,	Zinc,
		nitrogen,	Arsenic,									
		mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
DTX1	3/25/2008	2.73	1.6	0.18	<0.24	<2.0	<0.16	<0.010	3.5	18.3	7.4	<3.6
DTX1	6/25/2008	2.97	1.7	0.16	E.15	<2.0	<.16	<.010	3.4	17.2	12.7	<3.6
DTX1	9/17/2008	3.08	1.3	0.23	<.60	<5.0	<.40	<.010	2.6	19.1	11.7	<9.0
DTX1	11/18/2008	3.08	1.5	0.20	<.36	<3.0	<.18	<.010	2.7	16.2	13.2	<6.0
DTX2	3/25/2008	<.04	0.84	E.06	<.36	<3.0	<.24	<.010	1.8	6.7	0.30	<5.4
DTX2	6/24/2008	<.04	0.78	E.07	0.39	<3.0	<.24	<.010	2.0	8.8	0.29	<5.4
DTX2	9/17/2008	<.04	0.72	<.20	<.60	<5.0	<.40	<.010	1.8	9.6	0.23	<9.0
DTX2	11/18/2008	<.40	0.94	<.08	<.48	<4.0	<.24	<.010	1.9	8.0	E.17	<8.0
DTX8A	6/24/2008	<.04	0.12	<.04	0.13	<1.0	<.08	<.010	0.5	1.1	0.07	<1.8
DTX10A	6/23/2008	<.04	0.15	<.08	0.25	<2.0	<.16	<.010	1.4	3.6	0.17	<3.6
D6	3/26/2008	38.8	1.5	<.32	<.96	<8.0	<.64	<.010	3.6	11.0	57.1	<14.4
D6	6/23/2008	39.4	1.6	E.14	<.84	<7.0	<.56	<.010	4.1	13.7	61.8	<12.6
D6	9/18/2008	41.4	1.2	<.40	<1.2	<10.0	<.80	<.010	3.2	14.3	60.6	<18.0
D6	11/19/2008	40.4	1.3	<.20	<1.2	<10.0	<.60	<.010	3.4	11.5	65.1	<16.0
D17	3/25/2008	0.85	1.4	<.04	<.12	<1.0	<.08	<.010	5.3	0.66	7.4	<1.8
D17	6/25/2008	0.85	1.5	E.02	<.12	<1.0	<.08	<.010	5.5	0.88	7.6	<1.8
D17	9/19/2008	0.88	1.6	<.04	<.12	<1.0	<.08	<.010	5.5	0.78	8.8	<1.8
D17	11/18/2008	0.89	1.5	E.02	<.12	<1.0	<.06	<.010	5.6	0.88	7.7	<2.0
D25	3/26/2008	0.50	1.5	0.16	<.24	<2.0	<.16	<.010	6.1	6.1	0.97	<3.6
D25	6/25/2008	1.44	1.6	0.20	E.15	<2.0	<.16	<.010	6.9	7.2	1.9	<3.6
D25	9/16/2008	3.11	2.3	0.24	<.60	<5.0	<.40	<.010	10.2	13.6	4.2	<9.0
D25	11/19/2008	0.32	1.7	0.24	<.36	<3.0	<.18	<.010	7.3	7.5	0.75	<6.0
Human Health or Drinking Water Standard		10	10	5	100	1,000	50	2	35	100	50	5,000
Agricultural Standard		100	100	10	100	200	100	10	None	200	20	2,000

Surface Water (Streambed Sediment)



Approach

Surface-water contamination is a concern for the stakeholders, but streams flow off the Metro District properties only during runoff when surface-water sampling is impractical. Therefore, possible surface-water contamination from metals is evaluated by sampling streambed sediments soon after storms. Two small drainage basins were selected for similar characteristics but different land use—one drainage basin in a biosolids-application field and another drainage basin in a farmed field (not on the Metro District properties) that does not receive biosolids. A downstream part of each of the two drainage basins was sampled after the same storms once each year (if samples can be collected) for inorganic constituents (including metals, total nitrogen, and total phosphorous) and organic carbon. Data were reviewed and statistically tested to determine if concentrations are significantly different between the two drainage basins.

Progress Last Period (January--December 2008)

The site was carefully monitored for runoff-producing rainfall. Runoff in the monitoring locations (see page 2) was not sufficient to enable streambed-sediment sampling during this period.

Information for the Current Period (January--December 2009)

The land use at the control site has changed. Therefore, there are no plans to collect additional streambed-sediment samples.

Biosolids

Approach

Biosolids samples are collected as one- to two-day composites from the centrifuges at the Metro District plant and analyzed for trace elements through the USGS. The material is placed in one-gallon plastic or glass bottles and transported to the USGS in Denver. There, the samples are air-dried then ground to less than 150 micrometers. Biosolids are sampled and analyzed at least monthly. Data are reviewed and compared to Federal and State regulatory limits.



Progress Last Period (January--December 2008)

Biosolids samples were collected each month during 2008. Inorganic chemical analyses were completed and compiled for all biosolids samples collected through December 2008. The USGS released comprehensive data reports containing analytical data for biosolids samples from 1999-2006 (USGS OFR 2008-1172) and from 2007 (USGS OFR 2008-1358); these reports are available at the USGS website listed on page 1. The USGS continues to research the fate and transport of organic wastewater compounds (emerging contaminants) related to land application of biosolids.

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Information for the Current Period (January--December 2009)

The organic wastewater compounds analyses for the selected 2006 biosolids samples were completed. The USGS released a report for biosolids samples from 2008 (USGS OFR 2009-1090); this report is available at the USGS website listed on page 1. The 2009 biosolids samples will be collected and prepared for inorganic chemical analysis.

USGS biosolids data for samples collected from the treatment plant January through December 2008

[Data are preliminary and subject to revision. Table 1 and Table 3 standards from Colorado Department of Public Health and Environment, 2003, Biosolids regulation, 5CCR 1002-64: April 14, 2003, variously paginated; ppm, parts per million; %, percent]

Sample Date	Arsenic, ppm	Cadmium, ppm	Copper, ppm	Mercury, ppm	Molybdenum, ppm	Nickel, ppm	Lead, ppm	Selenium, ppm	Sulphur, %	Zinc, ppm
January 2008	2.8	2.0	706	0.96	19.8	18	38	12	1.61	745
February 2008	1.4	2.1	755	1.18	20.8	19	37	11	1.60	768
March 2008	1.2	1.9	706	0.97	18.0	17	36	8.6	1.53	754
April 2008	2.6	1.8	666	1.02	19.3	18	41	8.8	1.57	714
May 2008	4.0	2.2	767	1.18	18.8	19	45	10	1.59	779
June 2008	3.5	3.0	800	1.25	22.6	19	42	11	1.70	880
July 2008	3.6	3.1	670	1.30	22.8	17	38	10	1.65	805
August 2008	4.4	3.4	861	1.22	26.0	21	46	11	1.72	990
September 2008	4.5	3.2	689	1.30	21.2	18	41	12	1.68	860
October 2008	3.8	2.6	679	1.16	21.1	18	38	11	1.60	850
November 2008	3.8	2.8	728	1.40	21.8	19	43	12	1.66	861
December 2008	3.8	2.5	733	0.95	24.5	19	41	12	1.60	870
Table 3 Standard	41	39	1,500	17	75 (Table 1 Standard)	420	300	100	None	2,800

USGS plutonium data for biosolids samples collected January 2007 through December 2008

[Data are preliminary and subject to revision. pCi/g, picocuries per gram; +/-, plus or minus the analytical uncertainty; analytical uncertainty is the 1-sigma total combined standard uncertainty provided by the laboratory]

Sample Date	Plutonium 238, pCi/g	Plutonium 238, minimum detectable concentration, pCi/g	Plutonium 239+240, pCi/g	Plutonium 239+240, minimum detectable concentration, pCi/g
June 2007	-0.003 +/- 0.017	0.1	0.0018 +/- 0.0018	0.1
June 2008	-0.003 +/- 0.017	0.1	-0.0023 +/- 0.0034	0.1

Soil

Approach

One site was selected for characterizing and monitoring the chemical composition of soil on the Metro District property in Arapahoe County, and one site was selected on the Metro District property in Elbert County. Each site consists of three 20-acre (933 feet by 933 feet) fields separated by 100-foot buffer zones. The center 20-acre field at each site receives biosolids applications. The other two 20-acre fields at each site do not have biosolids applied and are used as “control” fields to monitor the natural variability of soil composition for the duration of the study. All three 20-acre fields at each site are farmed in the normal fashion and have crops planted and harvested. Soils from each of the six fields will be sampled in 2010. Samples are analyzed for arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. Data are examined to determine if concentrations have changed with time.



Progress Last Period (January--December 2008)

No soil samples were collected by the USGS during this period.

Information for the Current Period (January--December 2009)

No soil samples will be collected by the USGS during this period, but the sampling fields are maintained as described in the approach. The USGS released a comprehensive report for soil samples from 1999 through 2003 (USGS OFR 2009-1111); this report is available at the USGS website listed on page 1.

Crops

Approach

Crops from each of the six 20-acre soil-monitoring fields are chemically analyzed after harvest. Analyses include arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc.



Progress Last Period (January--December 2008)

Crop samples (wheat from the 2008 harvest) were received from the soil-monitoring fields in Arapahoe County. Samples were processed for analysis.

Information for the Current Period (January--December 2009)

The crop samples provided to the USGS from the Arapahoe County soil-monitoring fields in 2008 were analyzed. Crop samples (wheat from the 2009 harvest) were received from the soil-monitoring fields in Elbert County.

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USGS data for harvested crop-grain samples collected summer 2008

[Data are preliminary and subject to revision; reported as dry weight basis; %, percent; ppm, parts per million; <, less than]

Sample Description	Grain type	Arsenic, ppm	Cadmium, ppm	Copper, ppm	Lead, ppm	Molybdenum, ppm	Nickel, ppm	Zinc, ppm
Arapahoe County, north control field	wheat	<0.02	0.031	2.4	<0.008	0.69	0.56	22.0
Arapahoe County, biosolids-applied field	wheat	<0.02	0.030	4.1	<.008	0.94	0.74	24.7
Arapahoe County, south control field	wheat	<0.02	0.033	4.3	<.008	0.80	0.80	34.9
Elbert County, biosolids-applied field	corn	<0.02	0.005	2.0	<.008	0.30	0.25	23.9

Dust**Approach**

A monitoring component for dust was added to the program in 2006 because dust quantities and contamination from biosolids-applied farmland are concerns for some stakeholders. The USGS met with selected stakeholders on January 13, 2006, to evaluate dust-sampling sites. Two farmed fields were selected for similar characteristics—one field in a biosolids-applied area and another farmed field (not on the Metro District properties) upwind that does not receive biosolids. Dust traps were installed adjacent to each field. The dust traps at both fields were sampled at the same time for dust quantity and inorganic constituents. Dust samples were collected approximately monthly during late winter through spring (the reported windiest time of the year) for two consecutive years (2006 and 2007).

**Progress Last Period
(January--December 2008)**

A report about the dust results was written and reviewed.

**Information for the Current Period
(January--December 2009)**

The USGS released the report about the dust results (USGS OFR 2008-1361); this report is available at the USGS website listed on page 1.

Definitions

Analytical uncertainty—The possible range of the true value or error term contributed by bias and variability of the laboratory measurement technique. All laboratory data have associated uncertainty. Each sample value should be thought of as a range in concentration defined by the reported value plus or minus the analytical uncertainty. The true concentration usually is somewhere in this range, but is not a precisely known point. For most analyses, the analytical uncertainty is not calculated for each sample but is estimated from bias and variability data derived from

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analyses of quality-assurance samples like blanks and replicates. For plutonium data, the analytical uncertainty is calculated individually for each sample for each analyte based on analytical and statistical variables.

Biosolids—Solid organic matter recovered from a sewage-treatment process that meets regulatory criteria for beneficial use, such as for fertilizer. Metro District applies Table 3, Class B biosolids near Deer Trail. Regulations require that land-applied biosolids must meet or exceed Table 1, Class B requirements. Table 3 Ceiling Concentration Limits are stricter than Table 1 Ceiling Concentration Limits.

Less than (<)—A designation for analytical results to indicate that a constituent was not present or was present at very low levels that the laboratory could not reliably determine. Note that the actual amount of this constituent in that sample is unknown and could be any amount between zero and the “less than” value.

Organic wastewater compounds—Chemicals that are used every day in homes, industry, and agriculture that may be found in small concentrations in biosolids, in water released from wastewater treatment plants, or in other water impacted by humans. These chemicals include detergents, disinfectants, fragrances, fire retardants, pharmaceuticals, hormones, and pesticides.

Runoff—The water from precipitation that flows over the land surface into valleys instead of infiltrating into the soil. Runoff can wash particles of soil, rock, plants, and biosolids from the land surface into the streambeds of the valleys.

Stakeholder—Any person or group (including the Metro District) interested or concerned about the Expanded Monitoring Program.

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***Eleventh annual
stakeholder meeting
is planned for September 23,
2009,
at the Metro Wastewater
Reclamation District property
near Deer Trail, Colorado***

*Prepared by Tracy Yager, Dave Smith,
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