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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 throughout their properties near Deer Trail, Colorado (see page 2). 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:

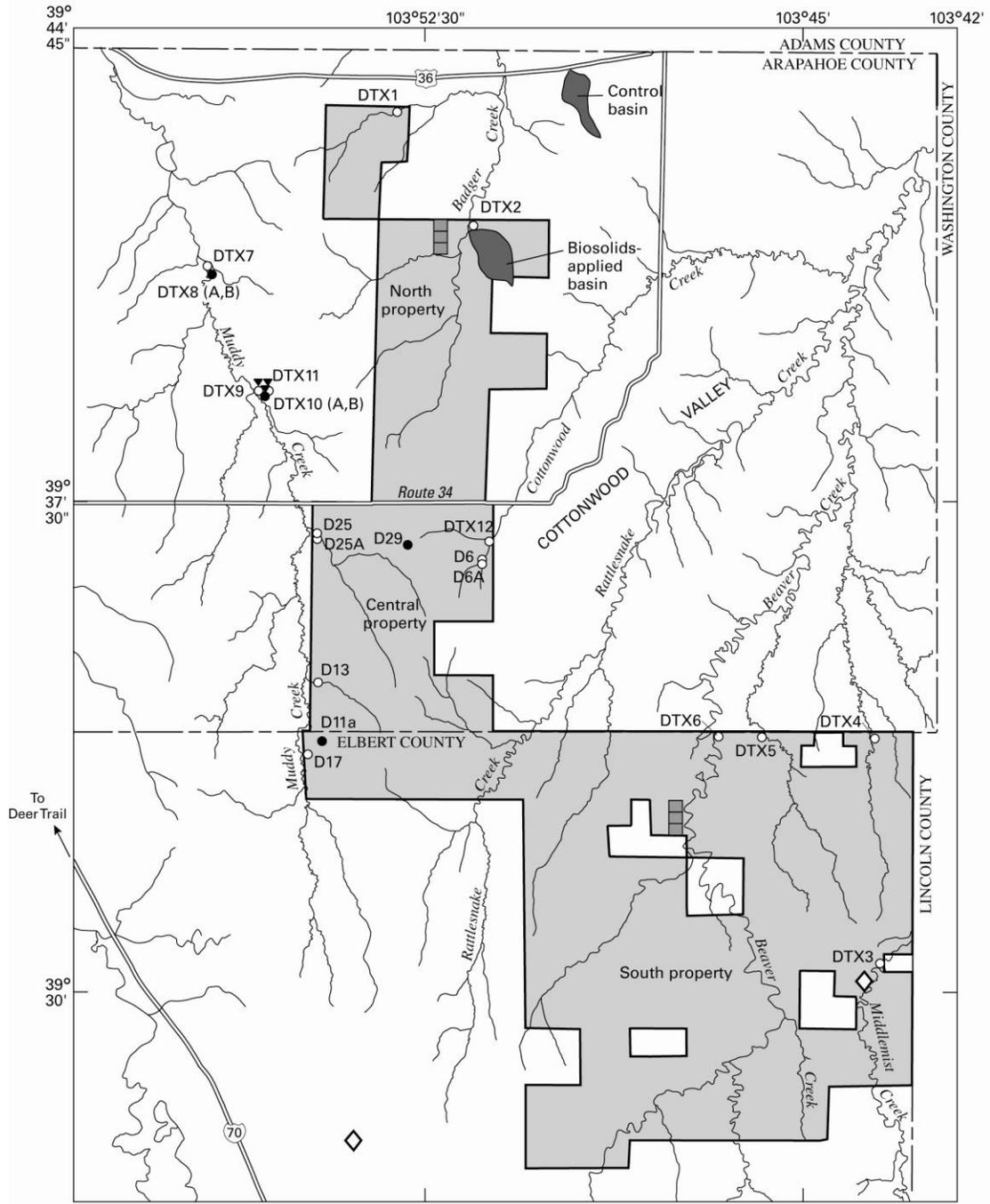
<http://co.water.usgs.gov/projects/CO406/index.html>

The address for just the continuous-recorder data is:

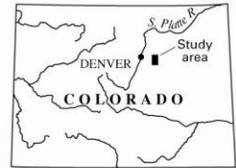
<http://co.water.usgs.gov/projects/CO406/data.html>

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 (MetroGro Farm, 1999 boundaries)
- Streambed-sediment sampling area
- Soil- and crop-sampling area
- USGS alluvial-aquifer monitoring well and identifier
- USGS bedrock-aquifer monitoring well and identifier
- Monitoring well with continuous recorder and identifier
- Dust-sampling location

Location of study area and U.S. Geological Survey monitoring sites near Deer Trail, Colorado, 2009. (Metro Wastewater Reclamation District property boundaries shown are from 1999.)

Continued from page 1

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 2009)

The annual stakeholder meeting was held September 23, 2009, at the Metro District shop building near Deer Trail, Colorado. 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. Presentations about the USGS work on organic wastewater compounds in biosolids were prepared and presented August 5, 2009, at a conference about compounds of emerging concern in Fort Collins, Colorado, and December 3, 2009, to the Consortium for Research and Education on Emerging Contaminants (CREEC) at a meeting in Arvada, Colorado.

Information for the Current Period (January--December 2010)

An annual stakeholder meeting scheduled for September 22, 2010, 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. The USGS met with the Metro District and stakeholders to discuss plans for the next USGS Expanded Monitoring Program Near Deer Trail, the phase for 2012-2017. Proposals for the 2012-2017 program were prepared by the USGS based on these discussions. A plan for interim monitoring will be made for 2011.

Questions & Answers

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 happens after 2010?

A: The USGS is in discussion with the Metro District and various stakeholders about a possible next phase of study for 2012 through 2017. In addition, the USGS and the Metro District are discussing an interim monitoring effort for 2011 that could include groundwater sampling and analysis.

Q: Why were some of the USGS monitoring wells closed in 2009?

A: USGS monitoring wells on the MetroGro Farm Central Property (see page 2) that were damaged or no longer needed were closed to protect groundwater resources in the area. Damaged wells can provide a conduit for surface contaminants like bird feces or farm chemicals to contaminate the groundwater. Some wells on the interior part of the Central Property were no longer needed for current study objectives. However, wells in good condition that showed degraded water quality relative to previous sample data (often from 1997-1998) were left open to enable continued monitoring of water quality at these sites. A well that was damaged in 2008 (well D30) but was needed for current study objectives was closed because it could not be repaired. The damaged well was replaced in 2009 by a new monitoring well, DTX12 (see photograph above).

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.



Continued on page 5

Continued from page 4

Progress Last Period (January--December 2009)

Depth to groundwater was measured monthly. Groundwater was sampled quarterly for routine chemistry. Many of the old wells from the first phase of monitoring at the MetroGro Farm were permanently closed. A replacement for well D30 (damaged and closed in 2008) was installed—DTX12 (see page 2). Groundwater data were compiled and reviewed.

Information for the Current Period (January--December 2010)

The USGS met with the Metro District and stakeholders to discuss plans for the next USGS monitoring program near Deer Trail (the phase for 2012-2017). Proposals for the 2012-2017 program were prepared by the USGS based on these discussions. A plan for interim monitoring will be made for 2011. Depth to groundwater will be measured approximately monthly. Groundwater at selected sites will be sampled and analyzed quarterly. Data will be compiled and reviewed.

USGS groundwater data for samples collected January through December 2009

[Data are preliminary and subject to revision. Standards from Colorado Department of Public Health and Environment, 2009, The basic standards for groundwater, 5CCR 1002-41: October 13, 2009, 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 nitrogen, mg/L	Arsenic, µg/L	Cadmium, µg/L	Chromium, µg/L	Copper, µg/L	Lead, µg/L	Mercury, µg/L	Molybdenum, µg/L	Nickel, µg/L	Selenium, µg/L	Zinc, µg/L
DTX1	3/4/2009	3.30	1.6	0.20	<0.24	<2.0	<0.12	<0.010	2.8	15.5	13.6	E2.1
DTX1	5/21/2009	3.40	1.6	.14	<.24	<2.0	<.12	<.010	2.4	12.6	12.4	<4.0
DTX1	9/9/2009	3.33	1.6	.12	E.34	<5.0	<.30	<.010	1.7	9.8	20.1	<10.0
DTX1	11/24/2009	3.86	1.8	.14	E.16	E1.1	<.06	<.010	1.8	14.1	12.6	<5.6
DTX2	3/4/2009	.04	.71	.06	<.36	<3.0	<.18	<.010	1.7	6.9	E.15	<6.0
DTX2	5/21/2009	.06	.63	.07	<.36	<3.0	<.18	<.010	1.7	4.4	.36	<6.0
DTX2	9/9/2009	<.04	.76	E.07	<.60	<5.0	<.30	<.010	1.8	10.0	.33	<10.0
DTX2	11/24/2009	<.04	.93	E.04	E.26	<3.0	<.09	<.010	1.9	16.1	.53	<8.4
DTX8A	5/20/2009	<.04	.08	<.02	<.12	<1.0	<.06	<.010	.5	1.9	.06	<2.0
DTX10A	5/19/2009	<.04	E.07	<.04	<.24	<2.0	<.12	<.010	1.2	3.2	.15	<4.0
D6	3/3/2009	46.0	1.5	E.14	<.96	<8.0	<.48	<.010	5.1	14.4	104	<16.0
D6	5/20/2009	50.4	1.2	<.16	<.96	<8.0	<.48	<.010	3.2	14.1	79.3	<16.0
D6	9/10/2009	52.6	1.4	E.15	E.98	<10.0	<.60	<.010	3.6	13.4	85.9	<20.0
D6	11/25/2009	53.2	1.9	.19	.87	<7.0	<.21	<.010	3.9	21.8	119	<19.6
D17	3/3/2009	.93	1.4	.03	<.12	<1.0	<.06	<.010	5.6	.73	8.4	<2.0
D17	5/19/2009	.99	1.6	.02	<.12	<1.0	<.06	<.010	5.6	.51	8.8	<2.0
D17	9/9/2009	.96	1.7	E.02	E.10	<1.0	<.06	<.010	5.7	1.1	9.1	<2.0
D17	11/24/2009	.95	1.5	.03	<.12	<1.0	<.03	<.010	5.4	1.6	8.9	<2.8
D25	3/4/2009	E.03	1.4	.20	<.24	<2.0	<.12	<.010	6.3	6.7	.44	<4.0
D25	5/21/2009	1.15	1.5	.22	<.24	<2.0	<.12	<.010	6.8	3.4	1.4	<4.0
D25	9/10/2009	1.66	2.1	.25	<.60	<5.0	<.30	<.010	7.8	16.2	1.8	<10.0
D25	11/25/2009	.23	2.1	.21	.30	E1.2	<.06	<.010	7.4	19.3	.75	<5.6
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 2009)

Because the land use at the control site (see page 2) changed, rainfall was no longer monitored at the sampling locations (shown on page 2) and streambed sediment was not sampled during this period.

Information for the Current Period (January--December 2010)

The former control site (see page 2) is no longer farmed, so it is not an appropriate control for the biosolids-site samples. Therefore, there are no plans to collect additional streambed-sediment samples at this time.

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 by the USGS at least monthly. Data are reviewed and compared to Federal and State regulatory limits.



Progress Last Period (January--December 2009)

Biosolids samples were collected each month during 2009. Inorganic chemical analyses were completed and compiled for all biosolids samples collected through December 2009. The USGS released comprehensive data reports containing analytical data for biosolids samples from 2008 (USGS OFR 2009-1090); this report is 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.

Continued on page 7

Continued from page 6

Information for the Current Period (January--December 2010)

The 2010 biosolids samples will be collected and prepared for inorganic chemical analysis. A biosolids sample from 2009 and a biosolids sample from 2010 were sent to the appropriate laboratory for plutonium analysis.

USGS biosolids data for samples collected from the treatment plant January through December 2009

[Data are preliminary and subject to revision. Table 1 and Table 3 standards from Colorado Department of Public Health and Environment, 2008, Biosolids regulation, 5CCR 1002-64: January 14, 2008, 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	Sulfur, %	Zinc, ppm
January 2009	1.34	1.9	630	1.05	22.0	16.9	37.2	13.4	1.49	731
February 2009	1.17	1.9	634	1.73	22.0	16.9	45.4	14.3	1.67	709
March 2009	1.31	2.0	665	1.56	21.4	73.8	43.2	13.7	1.69	739
April 2009	1.66	1.7	630	1.86	18.7	15.1	41.3	14.7	1.66	734
May 2009	1.63	1.5	647	1.42	18.6	15.4	38.9	15.5	1.67	731
June 2009	1.68	1.7	694	1.09	16.5	16.2	45.2	15.4	1.79	776
July 2009	1.89	2.0	703	1.43	16.9	17.1	43.8	15.4	1.85	848
August 2009	1.89	2.8	698	1.40	20.2	18.2	59.9	15.5	1.99	876
September 2009	1.86	3.1	686	1.47	21.4	17.6	48.2	15.5	2.01	878
October 2009	1.58	3.0	709	1.62	21.3	16.0	41.9	15.4	1.88	859
November 2009	1.42	2.7	638	1.21	21.6	17.1	40.9	15.5	1.76	776
December 2009	1.42	2.2	604	1.27	19.7	16.5	39.9	15.4	1.69	729
Table 3 Standard	41	39	1,500	17	75 (Table 1 Standard)	420	300	100	None	2,800

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 (see page 2). 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 2009)

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

Continued on page 8

Continued from page 7

Information for the Current Period (January--December 2010)

The sampling fields (see page 2) have received few biosolids applications since the last soil sampling in 2002. Therefore, the USGS determined that sampling soil in 2010 was premature. No soil samples will be collected by the USGS during this period, but the sampling fields are maintained as described in the approach so soil can be sampled in future years. 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 two soil-sampling areas (six 20-acre fields; see page 2) are chemically analyzed after harvest. Analyses include arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc.



Progress Last Period (January--December 2009)

Crop samples (wheat from the 2009 harvest) were received in August from the soil-monitoring fields in Elbert County. Samples were processed for analysis.

Information for the Current Period (January--December 2010)

The crop samples provided to the USGS from the Elbert County soil-monitoring fields in 2009 were analyzed. Crop samples (wheat from the 2010 harvest) were received in July from the soil-monitoring fields in Arapahoe County. A plan for interim monitoring will be made for 2011.

USGS data for harvested crop-grain samples collected summer 2009

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

Sample Description	Grain type	Arsenic, ppm	Cadmium, ppm	Copper, ppm	Lead, ppm	Mercury, ppm	Molybdenum, ppm	Nickel, ppm	Selenium, ppm	Zinc, ppm
Elbert County, north control field	wheat	<0.02	0.02	2.2	<0.01	<0.03	0.36	0.16	<0.1	15
Elbert County, biosolids-applied field	wheat	0.02	0.02	3.4	<0.01	<0.03	0.42	0.18	<0.1	12
Elbert County, south control field	wheat	0.03	0.01	2.3	<0.01	<0.03	0.36	0.16	<0.1	16

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 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.

Information for the Current Period (January--December 2010)

This study component is complete. No additional work is planned.

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 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.

Closed well—A well that has been permanently plugged and sealed in accordance with the State Engineer's rules for Colorado. In general, the surface casing of the well was removed, the inner casing was cut off below land surface and plugged (see photograph to right), and the land surface was reclaimed. Wells that were closed cannot be used for additional monitoring or other purposes.



Continued on page 10

Continued from page 9

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.

Contacts

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***Annual stakeholder
meeting
is planned for September 22,
2010, 6:00 p.m.,
at the Metro Wastewater
Reclamation District property
near Deer Trail, Colorado***

*Prepared by Tracy Yager, Dave Smith,
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Reclamation District, August 2010*

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