Sunnyside Cogeneration Associates

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October 17, 2017

Allan Moore
Solid Waste Program Manager
195 North 1950 West
Salt Lake City, UT 84116

RE: Sunnyside Cogeneration Associates (SCA)
SCA #2 Ash Landfill – CCR Ground Water Monitoring Requirements

Dear Mr. Moore,

Included is SCA's comprehensive groundwater monitoring and corrective action plan. SCA prepared a site-specific groundwater monitoring and corrective action plan pertaining to the SCA #2 Ash Landfill. The site-specific plan is designed to closely monitor groundwater quality and evaluate each constituent and compare with background levels to detect any potential statistically significant increases. The monitoring system includes one uphill and three downhill monitoring wells. Each of these four wells will be monitoring at least semi-annually throughout the active life and post closure period of the SCA #2 Ash Landfill.

The statistical method utilizing a control chart approach, with typical control limits of three standard deviations above the mean, is appropriate for evaluating the groundwater monitoring data for the SCA #2 CCR management area.

As required, this groundwater monitoring and corrective action plan meets the requirements of federal regulations 40CFR §257.90 thru 257.98 and corresponding Utah Code Rules R315-319-

90 thru R315-319-98 for an Existing CCR Landfill. The groundwater monitoring system has been designed and constructed to meet the requirements of Section R315-319-91.

If you have any questions regarding the permit documents enclosed, please contact Rusty Netz or myself at (435) 888-4476.

Thank you,

Gerald Hascall
Agent for
Sunnyside Cogeneration Associates

CC: Rusty Netz
SCA #2 Operating Record
Plant File

Section 6
Groundwater Monitoring and Corrective Action

Section 6 of this permit addresses the following regulatory sections:

R315-319-90;

R315-319-91;

R315-319-93;

R315-319-94;

R315-319-95;

R315-319-96;

R315-319-97;

R315-319-98;

6.1 Introduction

The existing SCA #2 Ash Landfill encompasses a footprint of approximately 30-40 acres resting against and into a small side hill with existing elevations ranging from approximately 6400 to 6775. This location was chosen because there is no surface water flowing in the vicinity and it is up above the valley floor with minimal potential for ground water under the landfill.

SCA #2 is an existing CCR landfill and is subject to the requirements under subsections R315-319-90 through 98. Groundwater monitoring is conducted utilizing three monitoring wells (MW-8, MW-9 MW-10) located downhill from the landfill and one monitoring well (MW-11) located uphill. See Figure 1 for locations.

SCA has designed and is constructing this landfill in a manner to minimize the potential for water to percolate through the CCR materials and reach the alluvial materials beneath the landfill. Dry climatic conditions in the region have a minimal opportunity for precipitation to come into contact with the CCR materials. The pozolanic properties of this CCR material tend to seal and solidify when in contact with water, thus reducing percolation. Surface runoff is directed off of the landfill and directed around the perimeter to the sedimentation pond. The aquifer consists generally of alluvial materials under the landfill, which are approximately 30-50 feet thick and allow water, if any, to flow down to the lower end of the landfill where it can be detected in the downhill monitoring wells or be captured in the sedimentation pond. The mancos shale formation comprises the confining unit defining the lower boundary of the aquifer and is thousands of feet thick and forms an impervious layer under the landfill. Closure plans for the landfill will require a soil cover material over the CCR ash material and revegetation to further reduce potential infiltration into the landfill.

As noted, this area is dry and has very little groundwater. Generally, monitoring wells MW-9, MW-10 and MW-11 are dry. MW-8 generally has water which has been flowing along the mancos shale layer and is naturally of poor water quality. Natural variations in groundwater quality in mancos shale areas have been studied extensively and tend to exhibit wide swings in concentrations of various constituents. This is typical of the background water quality observed at MW-8.

This plan identifies the Groundwater Monitoring and Corrective Action Plans in place at the existing SCA #2 Ash Landfill. This plan describes the monitoring system, monitoring frequencies, sampling, analyses, reporting, comparison to background, assessment steps to take in event of detecting statistically significant increases, methods of determining potential corrective measures and implementation of a corrective remedy if needed.

6.2 Groundwater Monitoring System

SCA has installed and is monitoring groundwater conditions at four monitoring wells around the perimeter of the SCA#2 Ash Landfill. These wells are located at the approximate latitude/longitude and elevations.

MW-11	N 39°32'31.0" and W 110°22'40.6" with elevation 6785 ft +/-
MW-10	N 39°32'20.5" and W 110°23'04.3" with elevation 6423 ft +/-
MW-9	N 39°32'18.0" and W 110°23'10.6" with elevation 6362 ft +/-
MW-8	N 39°32'18.6" and W 110°23'05.0" with elevation 6397 ft +/-

All four monitor wells (and the SCA#2 Ash Landfill) are located on private property owned by SCA. See well locations on figure below.

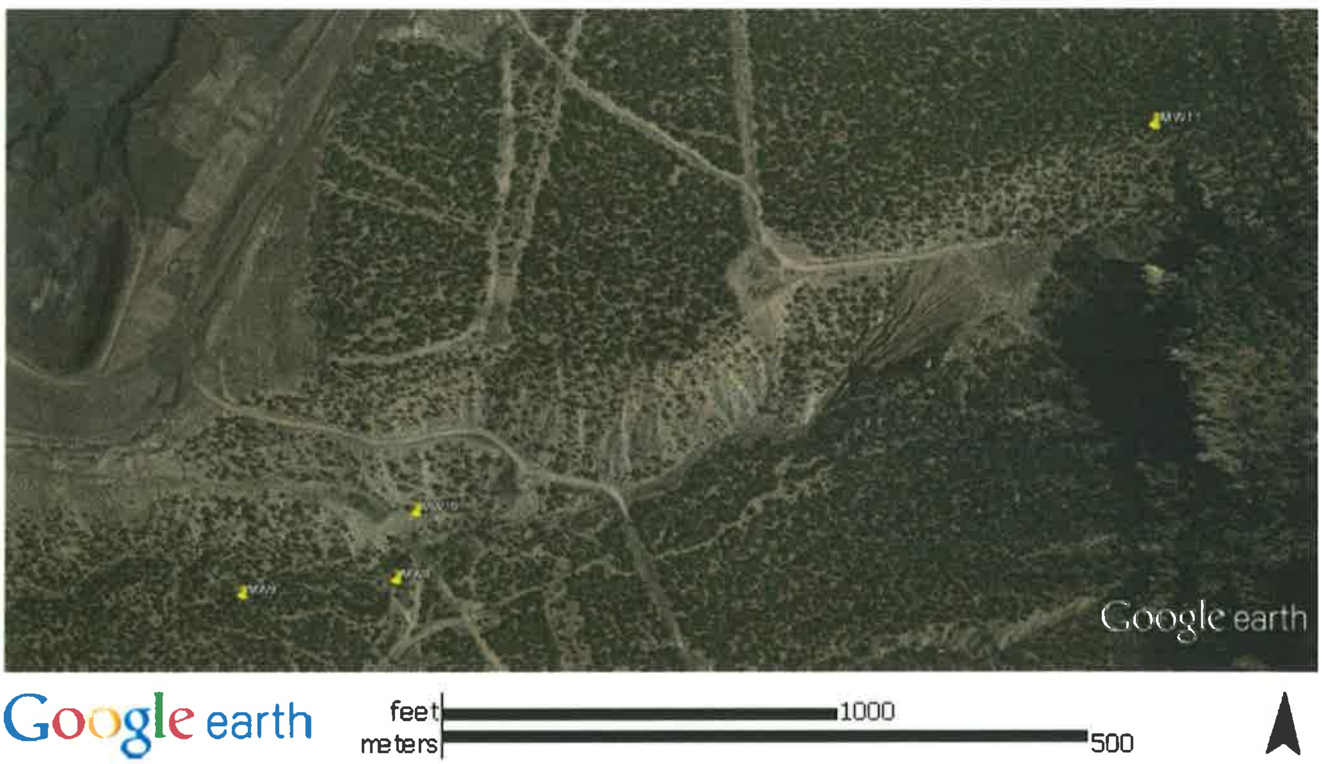

Figure 1. Monitor Well Locations – SCA#2 Ash Landfill

All four monitoring wells are installed in the alluvium with slotted pvc casing located just above the mancos shale layer. The annular space between the casing and the borehole was sealed above the sampling depth to prevent contamination of samples and the groundwater. Wells were located and installed in a manner to monitor groundwater conditions located both above and below the SCA#2 ash landfill. Detailed reports of the design, installation and development of each monitoring well are included in the operating record.

The four wells have been monitored to establish a background water quality. Wells MW-9, MW-10 and MW-11 have all been dry since installation. MW-8 has been sampled and analyzed on eight independent occurrences since the 40 CFR 257 was approved. Samples have been analyzed for all parameters listed in both Appendix III and Appendix IV to Rule 315-319. A summary of the analytical results of this sampling is included in this permit section under Appendix 6-A. Given that the SCA#2 Ash landfill began receiving CCR materials in 2015 and that it is a dry landfill, the groundwater aquifer monitored by samples taken from MW-8 are deemed to represent the quality of background water that has not been affected by leakage from the CCR landfill. Given that three of the four wells are dry, this is confirmation that groundwater under the landfill is very minimal which provides adequate basis for determining that the minimum number of wells is satisfactory for monitoring this aquifer.

Seasonal and yearly variations in precipitation have been seen to change the quantity of water percolating through the surface soils and thereby change the concentrations of different constituents in the groundwater quality. The time that ground water is in contact with the underlying mancos shale also impacts the quality.

6.3 Groundwater Sampling and Analysis Requirements

SCA has prepared a monitoring program with sampling procedures designed to ensure monitoring results that provide a consistent and accurate representation of groundwater quality at the monitoring wells. This program includes procedures and techniques for:

- Sample collection
- Sample preservation and shipment
- Analytical procedures
- Chain of custody control and

- Quality assurance and quality control

The monitoring program is described in detail in this permit section under Appendix 6-B. The program includes the following:

- Sampling and analytical methods appropriate for groundwater sampling on this site.
- Groundwater elevations are measured at each well, each time groundwater is sampled.
- Procedures for detection monitoring and for assessment monitoring and for corrective action.
- One representative sample is taken during each sampling event at each monitoring well. Wells that are dry during the sampling program are noted as such and no sample is taken.
- Background groundwater quality has been established as noted in Appendix 6-A. The statistical method utilizing a control chart approach, R315-319-93(f)(4), with a control limit for each constituent will be used in evaluating groundwater monitoring data for each specified constituent. The control limits established based on background water quality data for each constituent are included in Appendix 6-A.
- Seasonal and temporal variations in water quality data is evident in the background sampling that has occurred for the SCA#2 Ash Landfill and is commonly experienced throughout the region for groundwater impacted by the natural Mancos Shale formation. It is expected that these variations will continue to be seen throughout the life of the SCA#2 Ash Landfill monitoring program. As more data is collected over the years, it may be necessary to amend the control limits to acknowledge this natural variation.
- Upon sampling and analysis, SCA will compare the water quality results with the control limits established and determine if there is a statistically significant increase over the background values for each constituent required in the groundwater monitoring program. This comparison will occur within 90 days after sampling and analysis.
- Metals concentrations analyzed will measure "total recoverable metals" concentrations. Groundwater samples will not be field filtered prior to analysis.

6.4 Detection Monitoring Program

SCA will conduct a detection monitoring program at all monitoring wells associated with the SCA#2 Ash Landfill. This monitoring will occur at least semiannually throughout the active life of the SCA#2 Ash Landfill and through the post closure period.

The detection monitoring program will analyze for the constituents listed in Appendix III to Rule 315-319. These include the following:

- Boron
- Calcium
- Chloride
- Fluoride
- pH
- Sulfate
- Total Dissolved Solids (TDS)

A minimum of 8 independent samples from each well was collected and analyzed for the constituents listed in Appendix III and IV to Rule 315-319 prior to October 17, 2017. The analysis of these samples was used in establishing background water quality and the statistical control limits. Wells that were dry during the sampling program were noted as such and no sample was taken.

The detection monitoring program will include one representative sample taken at each monitoring well during each sampling event. Wells that are dry will be noted and no sample taken.

SCA will evaluate the results of ground water quality analyses, compare the water quality results with the control limits established and determine if there is a statistically significant increase over the background values for each constituent required in the groundwater monitoring program. This comparison will occur within 90 days after sampling and analysis.

In the event that a statistically significant increase is detected which cannot be demonstrated that a source other than the SCA#2 Ash Landfill caused the increase or that resulted in an error in sampling, analysis, statistical evaluation or natural variation in groundwater quality, SCA will begin monitoring under the established assessment monitoring program identified below.

If an alternate cause of the increase is demonstrated, SCA will obtain a certification from a qualified professional engineer verifying the accuracy of the information demonstrated. If such demonstration is completed within the 90 day period, SCA will continue to monitor in accordance with the Detection Monitoring Program. This demonstration will be included in the annual report.

In the event that monitoring begins in accordance with the established assessment monitoring program, SCA will prepare a notification stating such and provide such notification in accordance with recordkeeping requirements R315-319-105(h), notification requirements R315-319-106(h) and internet requirements R315-319-107(h).

6.5 Assessment Monitoring Program

If there is a statistically significant increase over the background values for one or more constituent in the Detection Monitoring Program, SCA will begin the following Assessment Monitoring Program within 90 days after sampling and analysis which triggers this assessment monitoring program.

The assessment monitoring program will include sampling and analysis of the ground water for all constituents listed in Appendix IV to Rule 315-319. These include the following:

- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Fluoride
- Lead
- Lithium
- Mercury
- Molybdenum
- Selenium
- Thallium
- Radium 226 and 228 combined

The assessment monitoring program will include one representative sample taken at each monitoring well during each sampling event. Wells that are dry will be noted and no sample taken.

Assessment monitoring will occur on the following schedule:

- Initial Assessment - within 90 days of triggering an assessment monitoring program – sample and analyze for all constituents listed in Appendix IV to Rule 315-319.
- Annually - sample and analyze for all constituents listed in Appendix IV to Rule 315-319.
- Semi-annually - sample and analyze for all constituents listed in Appendix III to Rule 315-319 (Detection monitoring) and also for those constituents from Appendix IV to Rule 315-319 which are detected in response to the Initial Assessment.

Groundwater protection standards will be established for the constituents detected in the Initial Assessment monitoring. Protection standards will be the higher of:

- Utah State established groundwater standards per rule R315-308, if such standard has been established for the detected constituent.

  or
- The upper control limit determined for the detected constituent in the background concentration specified in Appendix 6A.

Assessment monitoring information will be included in the annual report and will comply with recordkeeping and notification requirements.

Assessment monitoring will continue until all constituents listed in both Appendix III and IV of Rule 315-319 are below established background values listed in Appendix 6A.

If one or more constituents listed in Appendix IV of Rule 315-319 is detected at statistically significant levels above the groundwater protection standard established, SCA will determine whether the increased levels are the result of a release from the SCA#2 Ash Landfill from another source or are the result of an error in sampling, analysis, statistical evaluation or is natural variation in groundwater quality. SCA will prepare a notification identifying the constituents which exceeded the protection standard and an explanation of the cause.

- If this increase is not caused by a release from the SCA#2 Ash Landfill, this notice will include the demonstration that a source other than the SCA#2 Ash Landfill caused the increase or that the increase is a result of an error in sampling, analysis, statistical evaluation or is a natural variation in groundwater quality
- If this increase is caused by a release from the SCA#2 Ash Landfill, this notice will also characterize the nature and extent of any release which caused the increase and any

relevant site conditions that may affect the remedy ultimately selected. This characterization will include the components required under R315-319-95(g) and

- Land owners or residents directly over any part of a plume of contamination will be notified, and
- Initiate an assessment of corrective measures.

When all constituents listed in both Appendix III and IV of Rule 315-319 are shown to be at or below background upper control limit values listed in Appendix 6A for two consecutive sampling events, SCA will prepare, and submit to the State Director, a notice that SCA is returning to detection monitoring. The notice and response from the State Director will be placed in the facility's operating record.

6.6 Assessment of Corrective Measures

Within 90 days of finding that any constituent listed in Appendix IV to rule 315-319 has been detected at a statistically significant level exceeding the groundwater protection standard, and a determination that the increase is caused by a release from the SCA#2 Ash Landfill, SCA will initiate an assessment of corrective measures to:

- prevent further releases,
- remediate any releases which had occurred and
- restore affected area to original conditions.

This assessment will include an analysis of the effectiveness of the potential corrective measures in meeting all of the requirements and objectives of the remedy, including at least the following:

- Performance, reliability, ease of implementation, potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;
- The time required to begin and complete the remedy;
- The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

SCA will discuss the results of the corrective measures assessment at least 30 days prior to the selection of remedy, in a public meeting with interested and affected parties.

The demonstration will be certified by a qualified professional engineer attesting to its accuracy. This assessment and demonstration will also be included in the annual report.

During the period of assessing corrective measures, SCA will continue to monitor groundwater in accordance with the Assessment Monitoring Program

6.7 Selection of Remedy

Upon completing the corrective measures assessment, and reviewing the assessment in a public meeting, SCA will select a remedy that meets the following standards:

- Be protective of human health and the environment;
- Attain the groundwater protection standard as specified pursuant to Subsection R315-319-95(h);
- Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in appendix IV to Rule R315-319 into the environment;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems;
- Comply with standards for management of wastes as specified in Subsection R315-319-98(d).

In selecting a remedy that meets the above standards, SCA will also consider the following evaluation factors:

- The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful based on consideration of the following:
  - Magnitude of reduction of existing risks;
  - Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;

- The type and degree of long-term management required, including monitoring, operation, and maintenance;
- Short-term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal of contaminant;
- Time until full protection is achieved;
- Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment;
- Long-term reliability of the engineering and institutional controls; and
- Potential need for replacement of the remedy.

- The effectiveness of the remedy in controlling the source to reduce further releases based on consideration of the following factors:
  - The extent to which containment practices will reduce further releases; and
  - The extent to which treatment technologies may be used.
- The ease or difficulty of implementing a potential remedy(s) based on consideration of the following types of factors:
  - Degree of difficulty associated with constructing the technology;
  - Expected operational reliability of the technologies;
  - Need to coordinate with and obtain necessary approvals and permits from other agencies;
  - Availability of necessary equipment and specialists; and
  - Available capacity and location of needed treatment, storage, and disposal services.
- The degree to which community concerns are addressed by a potential remedy(s).

SCA will include with the selected remedy a schedule for implementing and completing the selected remedial activities. The schedule shall include a reasonable period of time considering the following:

- Extent and nature of contamination, as determined by the characterization required under Subsection R315-319-95(g);
- Reasonable probabilities of remedial technologies in achieving compliance with the groundwater protection standards established under Subsection R315-319-95(h) and other objectives of the remedy;

- Availability of treatment or disposal capacity for CCR managed during implementation of the remedy;
- Potential risks to human health and the environment from exposure to contamination prior to completion of the remedy;
- Resource value of the aquifer including:
- Current and future uses;
    - Proximity and withdrawal rate of users;
    - Groundwater quantity and quality;
    - The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to CCR constituents;
    - The hydrogeologic characteristic of the facility and surrounding land; and
    - The availability of alternative water supplies; and
- Other relevant factors as required by the Director.

6.8 Implementation of Corrective Action Program

Within 90 days of selecting the remedy as described above, SCA will initiate the selected remedial activities based on the schedule described above. The corrective action program will:

- Establish and implement a corrective action groundwater monitoring program that:
    - At a minimum, meets the requirements of an assessment monitoring program under Subsection R315-319-95;
    - Documents the effectiveness of the corrective action remedy; and
    - Demonstrates compliance with the groundwater protection standard pursuant to Subsection R315-319-98(c).
- Implement the corrective action remedy selected under Subsection R315-319-97; and
- Take any interim measures necessary to reduce the contaminants leaching from the CCR unit, and/or potential exposures to human or ecological receptors. Interim measures shall, to the greatest extent feasible, be consistent with the objectives of and contribute to the performance of any remedy that may be required pursuant to Subsection R315-319-97. The following factors shall be considered by an owner or operator in determining whether interim measures are necessary:
    - Time required to develop and implement a final remedy;

- Actual or potential exposure of nearby populations or environmental receptors to any of the constituents listed in appendix IV of Rule R315-319;
- Actual or potential contamination of drinking water supplies or sensitive ecosystems;
- Further degradation of the groundwater that may occur if remedial action is not initiated expeditiously;
- Weather conditions that may cause any of the constituents listed in appendix IV to this part to migrate or be released;
- Potential for exposure to any of the constituents listed in appendix IV to Rule R315-319 as a result of an accident or failure of a container or handling system; and
- Other situations that may pose threats to human health and the environment.

Within 90 days of selecting the remedy as described above, SCA will initiate the selected remedial activities based on the schedule described above. The corrective action program will: Throughout the implementation period, SCA will periodically evaluate the effectiveness of the Corrective Action Program. If needed, SCA will work with the Director and modify the program and / or implement other methods or techniques that could improve the effectiveness and achieve compliance.

The Corrective Action Program and its selected remedies will be considered complete when:

- SCA demonstrates compliance with the groundwater protection standards established for the constituents detected in the Initial Assessment monitoring and has received Director approval.
- Compliance with the groundwater protection standards established for the constituents detected in the Initial Assessment monitoring has been achieved by demonstrating that the concentrations of the detected constituents have not exceeded the groundwater protection standard(s) for a period of three consecutive years.
- All actions required to complete the remedy have been satisfied.

Upon completion of the Corrective Active Program and its selected remedies, SCA will prepare a notification stating that the remedy has been completed. This notification will be submitted to and approved by the Director. SCA will obtain a certification from a qualified professional engineer attesting that the remedy has been completed in compliance with the requirements of

Subsection R315-319-98(c). The report has been completed when it is placed in the operating record as required by Subsection R315-319-105(h)(13).

SCA will comply with the recordkeeping requirements specified in Subsection R315-319-105(h), the notification requirements specified in Subsection R315-319-106(h), and the internet requirements specified in Subsection R315-319-107(h).

APPENDIX 6-A

Background Water Quality
MW8

Sunnyside Cogeneration Associates - SCA#2 Ash Landfill

Background Groundwater Quality MW-8

	Field Parameters			Appendix III - Constituents for Detection Monitoring						
Sample Date	Temp. (C)	pH (S.U.)	SC (umhos)	Boron (mg/l)	Calcium (mg/l)	Chloride (mg/l)	Fluoride (mg/l)	pH (S.U.)	Sulfate (mg/l)	TDS (mg/l)
November 23, 2015	10.9	7.71	9800	0.38	470	239	0.80	7.8	6800	11300
February 16, 2016	13.4	6.89	9670	0.33	404	226	0.50	7.2	6800	11000
March 9, 2016	12.9	6.78	9298	0.39	420	210	0.90	7.1	6500	10900
June 8, 2016	15.0	7.64	9032	0.35	432	210	1.00	7.2	6020	10700
August 2, 2016	14.7	6.88	8955	0.30	372	229	0.40	7.2	6470	10600
September 29, 2016	13.1	6.90	9540	0.32	393	245	0.40	7.1	6810	10100
November 22, 2016	12.0	7.24	9877	0.41	436	284	0.10	6.8	6990	12000
March 15, 2017	13.6	8.00	9987	0.35	449	363	0.40	7.2	7550	11500
Average	13.2	7.26	9520	0.35	422	251	0.6	7.2	6743	11013
Minimum result	10.9	6.78	8955	0.30	372	210	0.1	6.8	6020	10100
Maximum result	15.0	8.00	9987	0.41	470	363	1.0	7.8	7550	12000
Standard Deviation	1.3	0.44	363	0.03	30	48	0.3	0.3	415	549
Upper Control Limit	16.95	8.57	10609	0.46	510.7	394.2	1.42	7.98	7988	12659

Sunnyside Cogeneration Associates - SCA#2 Ash Landfill

Background Groundwater Quality MW-8

	Appendix IV - Constituents for Assessment Monitoring													
Sample Date	Antimony (mg/l)	Arsenic (mg/l)	Barium (mg/l)	Beryllium (mg/l)	Cadmium (mg/l)	Chromium (mg/l)	Cobalt (mg/l)	Fluoride (mg/l)	Lead (mg/l)	Lithium (mg/l)	Mercury (mg/l)	Molybdenum (mg/l)	Selenium (mg/l)	Thallium (mg/l)
November 23, 2015	0.005	0.0100	0.010	0.005	0.002	0.005	0.005	0.80	0.005	1.03	0.0000	0.005	0.1690	0.0020
February 16, 2016	0.005	0.0045	0.008	0.0005	0.002	0.005	0.0015	0.50	0.005	0.925	0.0002	0.0005	0.0753	0.0002
March 9, 2016	0.0005	0.0059	0.008	0.005	0.002	0.0008	0.0016	0.90	0.005	0.93	0.0002	0.0022	0.0588	0.002
June 8, 2016	0.005	0.0039	0.010	0.0005	0.002	0.0005	0.0016	1.00	0.005	0.937	0.0002	0.0005	0.0452	0.0002
August 2, 2016	0.0005	0.0041	0.008	0.0005	0.002	0.0018	0.002	0.40	0.005	0.951	0.0002	0.0019	0.0366	0.0002
September 29, 2016	0.0005	0.0056	0.009	0.0005	0.002	0.0014	0.0022	0.40	0.005	0.92	0.0002	0.0019	0.0445	0.0002
November 22, 2016	0.0005	0.0075	0.009	0.005	0.002	0.005	0.0024	0.10	0.005	1.01	0.0002	0.005	0.0997	0.002
March 15, 2017	0.005	0.0122	0.010	0.005	0.002	0.0018	0.0014	0.40	0.005	1.11	0.0002	0.005	0.2150	0.0002
Average	0.0028	0.0067	0.0090	0.0028	0.0020	0.0027	0.0022	0.5625	0.0050	0.9766	0.0002	0.0028	0.0930	0.0009
Minimum	0.0005	0.0039	0.0080	0.0005	0.0020	0.0005	0.0014	0.1000	0.0050	0.9200	0.0000	0.0005	0.0366	0.0002
Maximum	0.0050	0.0122	0.0100	0.0050	0.0020	0.0050	0.0050	1.0000	0.0050	1.1100	0.0002	0.0050	0.2150	0.0020
Standard Deviation	0.0023	0.0028	0.0009	0.0023	0.0000	0.0019	0.0011	0.2870	0.0000	0.0633	0.0001	0.0018	0.0612	0.0009
Upper Control Limit	0.0095	0.0151	0.0116	0.0095	0.0020	0.0082	0.0055	1.4234	0.0050	1.1664	0.0004	0.0083	0.2767	0.0035

Sample Date	Radium 226 (pCi/L)	Radium 226 LLD (pCi/L)	Radium 226 Variance (pCi/L)	Radium 228 (pCi/L)	Radium 228 LLD (pCi/L)	Radium 228 Variance (pCi/L)
November 23, 2015	0.90	0.10	0.20	1.00	0.30	0.30
February 16, 2016	1.30	0.21	0.18	1.10	0.23	0.29
March 9, 2016	1.40	0.17	0.16	1.40	0.22	0.29
June 8, 2016	1.30	0.15	0.25	1.40	0.24	0.32
August 2, 2016	1.30	0.16	0.18	1.20	0.28	0.34
September 29, 2016	1.30	0.07	0.17	1.20	0.27	0.33
November 22, 2016	1.70	0.43	0.28	3.00	0.39	0.51
March 15, 2017	1.60	0.24	0.18	0.76	0.29	0.32
Average	1.35	0.19	0.20	1.38	0.28	0.34
Minimum	0.90	0.07	0.16	0.76	0.22	0.29
Maximum	1.70	0.43	0.28	3.00	0.39	0.51
Standard Deviation	0.22	0.10	0.04	0.64	0.05	0.07
Upper Control Limit	2.02	0.50	0.32	3.31	0.43	0.54

APPENDIX 6-B

Groundwater Sampling and Analysis Requirements

GROUNDWATER SAMPLING AND ANALYSIS REQUIREMENTS

TABLE OF CONTENTS

1.0 INTRODUCTION

The collection of representative environmental data is neither a straightforward nor easily accomplished task. Measurements are subject to a wide variety of instrument, spatial, and temporal variables. A representative sample of the material from which it is collected must represent accurately the spatial, temporal, physical, and chemical qualities of the material. Standard operating procedures help to minimize those errors which would result in the collection of invalid data or non-representative samples. This is very important as field data collection is the primary basis upon which site investigations, assessments, and remedial actions are based.

There are four basic factors which affect the quality of sampling data. These include:

1) selection of the sample collection site;
2) method of sample collection;
3) sample preparation, preservation, and storage methods;
4) sample analysis.

Samples must be representative of the media from which they were extracted, and maintain their integrity and/or constituents between the time of sampling and the time of analysis. Field measurement devices and procedures also must follow set procedures to obtain precise and accurate readings at representative locations.

2.0 PRESAMPLING ACTIVITIES

2.1 COMMUNICATION WITH LABORATORY

Communication with laboratory personnel responsible for analysis of the samples prior to sample collection cannot be overemphasized. Lab personnel can be an important source of information and materials if they understand the specifics of the sampling program. Interaction with lab personnel usually improves program efficiency, and the accuracy and completeness of the results. Procedures and analyses being used should be established. Laboratory staff can often provide guidance and suggestions concerning particular problem areas that may develop. Laboratory staff should also understand the chain-of-custody, QA/QC, and labeling procedures that are employed throughout the investigation. Written instructions should be obtained from the laboratory for any non-routine procedures pertaining to sample preparation, preservation, and storage.

2.2 CONTAINER PREPARATION

It is important to use proper sample containers and preservation techniques to minimize the alteration of the sample chemistry between the field and the laboratory. Sample containers will be prepared by the laboratory. Proper preservation will be performed, the jars labeled, and the chain-of-custody initiated prior to any sample shipment. Container types and preservatives are shown in Table 1, reprinted from EPA SW-846. Methods of container preparation, sample preservation, sample storage, packing and shipping are discussed in Sections 4 and 5.

2.3 QUALITY CONTROL SAMPLES

Two types of quality control samples will be submitted to the chemical laboratory for analyses from time to time.

1) Field Blank – To determine the effect of sample handling procedures and the environment on the sample, a field blank will be collected from time to time. The water used must be free of the analytes to be tested for. The "blank" water will be poured into the sampling device, and then handled as an environmental sample: poured into bottles, preserved, shipped, and analyzed. The field blank must be collected after the sampling device has been decontaminated, but prior to collection of the next environmental sample. The source of the water utilized to generate the field blank will be noted.

2) FIELD DUPLICATE – A field duplicate is defined as two samples collected simultaneously at sampling location. Duplicate samples will have a sample number different from the original. Both the "false" and "true" sample numbers will be recorded. On the chain-of-custody forms, the "false" sample number will be used for the duplicate sample. This sample will be collected from time to time.

3.0 COLLECTION OF ENVIRONMENTAL SAMPLES

3.1 GROUNDWATER SAMPLING PROCEDURES

Prior to the start of sampling operations, information will be obtained in order to improve the efficiency and cost effectiveness of the sampling program. The specifics of the well construction, including the diameter of the well, the depth of the casing, the depth to the screened portion of the well, the total length of the screen, and the material used in the construction of the well and screen will be reviewed. The well diameter is important since it helps determine sampling equipment and procedures. The majority of wells used only for monitoring have two-inch outside diameter. However, in many cases where groundwater recovery was used to remediate a contamination problem, wells with either four, six, or eight-inch outside diameter well casings may have been used. It is also important to know the accessibility to the wells, which may affect the selection of the sampling equipment and transport of the equipment to the well. Prior to sampling, all well locations will be marked on a site map, the order in which the wells will be sampled will be determined, and specific equipment requirements will be developed.

A general checklist of equipment needed to sample groundwater monitoring wells follows:

1) Sample collection equipment (bailers, pumps).
2) Reagents for sample preservation provided by the laboratory (see Section 4.3).
3) Appropriate sample containers provided by the laboratory (see Section 4.4).
4) Meters, probes, and standards for desired on site measurements (see Section 4.5).

5) Appropriate field and trip blanks, and water.
6) Appropriate field duplicate sample containers.
7) Forms, labels, and tags
8) Monitoring well keys – many monitoring wells have locking caps, and keys are necessary to gain access. In addition, some sites are secured, in which case keys and/or permission are necessary.
9) Tools to assist in well access – these may include screw drivers, hammers, chisels, pipe, wrenches, chain, or a propane torch. All or any of these may be necessary for moving steel security caps on well which have not been opened recently.
10) Electronic water level indicator / graduated depth sounder – these are necessary to determine the static water level and the total depth of the well.
11) Pocket calculator – this is used to determine the number of well volumes to be evacuated from a well prior to sampling.
12) Log book and indelible ink marker. This is used to record field information.

The measurement of the well volume and water level will be conducted in the following fashion.

1) Measure inside diameter of the well.
2) In areas with possible non-aqueous phase floating compounds, the procedure outlined in Section 3.6 will be followed to measure the potential layer thickness prior to purging.
3) Measure the static water level from the top of the well pipe (not the protective casing) to within 0.01 ft., using an electronic well probe.
4) Determine the total depth of the well from either the well installation logs or direct measurement using an electronic well probe. All measurements are taken from the top of the well casing pipe.
5) Calculate the number of linear feet of static water standing in the well (difference between static water level and total depth of the well).
6) Calculate the static volume using the following table.

Casing Diameter (inches)	Volume per 100 Feet Casing (cf)	Volume per 100 Feet Casing (gal)
1.0	0.5	4
1.5	1.2	9
2.0	2.2	16
3.0	4.9	37
4.0	8.7	65
5.0	13.6	102
6.0	19.6	147

7) Rinse the probe and cord thoroughly with distilled water and methanol after each use to avoid possible cross contamination from other wells.

8) Remove at least three well volumes of groundwater prior to sample collection. In most cases, removal of three well volumes results in the collection of a representative groundwater sample not influenced by stagnant water remaining in the well casing. In

cases where it is suspected that the removal of only three well volumes may result in either under-evacuation or over-evacuation of a particular well, continuously monitor the pH, specific conductivity, and temperature while removing 10 well volumes from the well. It is recommended that this experiment be conducted several days before the actual collection of samples.

9) The pumping mechanism used to purge or evacuate the well is dependent upon the equipment available and the accessibility of the well. A variety of pumps may be used, including hand-operated or motor driven suction pumps, peristaltic pumps, and compressed gas or battery driven pumps. In some cases, hand bailing is the best method. The pumping method depends on the accessibility of the well, depth to water, and well diameter. If the pump being used does not have a flow meter, a graduated plastic pail can be used to measure the total discharge volume. If a pump that could alter the sample characteristics has been used to purge the well, the hose and rope should be removed from the pump and then decontaminated or stored in an appropriately labeled container, if each hose or rope is to be dedicated to the particular well. The pump used for evacuation should be dismantled and decontaminated. Dedicating equipment to each well is the preferred method.

10) Certain wells are slow to recharge, and it may be necessary to return several hours or even a day later in order to collect a sample. An alternative sampling method for which recharging slowly is to pump the well dry and collect the sample as water returns into the casing. Either method is acceptable and depends upon the analysis to be conducted, well accessibility, and the cost effectiveness.

The following procedure is recommended for obtaining groundwater samples from monitoring wells:

1) Various types of equipment may be used to purge a monitoring well. A bailer is recommended to be used to collect the sample. Although other equipment may be used if it does not affect the water sample's analytes of interest. The bailer can be made of Teflon, PVC (no glued joints), or stainless steel. The use of 3/8" braided nylon rope or fish line is recommended for lowering and raising the bailer.

2) To sample the water, slowly lower the bailer down the well until it is submerged, and then pull it out to the surface. Fill the sample bottles directly from the bailer to reduce the probability of cross-contamination and loss of volatile organic compounds. To avoid contamination of the rope, do not allow the rope to contact the ground; either hold it in hand or lay it on a sheet of plastic laid on the ground.

Groundwater chemistry is such that exposure of groundwater samples to atmospheric conditions can result in detectible alteration of the sample's chemical characteristics. To avoid these changes and to maintain sample representativeness, it is imperative that immediately upon collection, the samples be prepared, preserved, and stored in such a manner as to prevent any changes in sample chemistry from occurring. Refer to subsequent subsections of this document for sample preparation, preservation, storage, and in-field measurements procedures.

3.2 SURFACE WATER SAMPLING

The equipment needed for surface water sampling is usually minimal. In many instances, the sample container will serve as the sampling device. However, when analyzing dissolved metals, the sample must be transferred from the sampling device into a filtration apparatus for filtration prior to sample presentation and storage. A recommended list of surface water sampling equipment and accessories is as follows:

1) Materials for sample preparation (see Section 4.2).
2) Reagents for sample preservation (see Section 4.3).
3) Appropriate sample containers (see Section 4.4).
4) Meters, probes, and standard for desired on-site measurements (see Section 4.5).
5) Appropriate field and trip blanks. The type and number of blanks should be established with the laboratory conducting the analysis.
6) Forms, labels, and tags (see Section 5.4).
7) Sampling devices – These may include a Kemmerer bottle, the sample containers, or telescoping aluminum pole with an attached clamp and beaker. Due to problems which may result from the inaccessible nature of many surface sampling locations, field personnel are encouraged to draw upon their own experience and creativity in the design of an appropriate sampling device. All devices must be approved by the Project Manager prior to use.
8) Decontamination supplies – These will be used for decontaminating all equipment that comes into contact with the sample (see Section 4.1).
9) Log book and indelible ink marker – This is for recording field information.

Most surface water samples are taken as grab samples. Typically, surface water sampling involves immersing the sample container into the water body. The following suggestions are made to help ensure that the samples obtained are truly representative of the water body being sampled.

1) Generally, the most representative samples are obtained at mid-channel at one-half of the stream depth in a well-mixed stream.
2) Stagnated areas of pools, streams, or rivers may contain zones of pollutant concentration, depending upon the physical and chemical properties of the contaminants and the position of these stagnated waters relative to the sources of contamination.
3) Ordinarily sampling should be conducted beginning at the suspected zones of lowest contamination to the zones of highest contamination.
4) Excessive agitation of the water, which results in the loss of volatile constituents, should be avoided.
5) A water sample from the surface should not be taken unless sampling specifically for a non-aqueous phase layer floating on the water. Instead, the sample container should be inverted, lowered to the approximate depth, and then held at about a 45 degree angle with the mouth of the bottle facing upstream.

Generally, surface water samples are much more stable than groundwater samples. Surface waters, especially from streams under turbulent flow conditions, tend to be in equilibrium with atmospheric conditions, and therefore will not undergo significant changes in water chemistry after collection. However, it is best to appropriately preserve and store the samples, and to take field measurements immediately after sample collection as described in Sections 3.3, 4.1, 4.2, and 4.3 of this document.

3.3 NON-AQUEOUS PHASE LAYER SAMPLING

If a non-aqueous phase layer (NAPL) is present on the surface of the water in a groundwater monitoring well, the thickness of the NAPL will be measured and a sample of it collected, if necessary.

The NAPL thickness will be measured using one of two techniques. A battery operated device that measures NAPL thickness such as an ORS Interface Probe, will be used first if the thickness is unknown. The sensing probe is lowered slowly down the well until it senses liquid. The depth is recorded. The probe is lowered further down the well until it senses water. Then the probe is moved above and below the NAPL water interface 3 to 4 times to get an accurate interface depth reading, which is recorded.

If the NAPL is less than ¼ inch, a surface sampler will be used to measure the NAPL thickness. The sampler, similar to ORS Surface Samplers, is slowly lowered through the NAPL then brought to the surface for measurement and observation. A surface sampler can be used to also sample the NAPL for chemical analysis.

3.4 FIELD MEASUREMENTS

The decision to gather in-field measurements will depend upon the types of material being sampled, the geochemical environment in which the samples exist, and the desired end use of the collected data. For groundwater samples in particular, it is generally advisable to take in-field measurements of pH, specific conductance, and temperature. All of these parameters are susceptible to change upon contact with general atmospheric conditions. As such, if analyzed in the lab, the values for these parameters may not be representative of the true subsurface environment. Since surface waters, especially those from streams and creeks with turbulent flow, are actually at equilibrium with atmospheric conditions, in-field measurements of these parameters for stream samples is not as critical, but is still a recommended practice.

4.0 POST SAMPLE COLLECTION PROCEDURES

After a sample has been collected, it may need to be composited, filtered, preserved, and / or stored. The sampling equipment must also be decontaminated. Procedures for these operations are described in the following sections.

4.1 COMPOSITING

In cases where composite samples are collected, it may sometimes be desirable to combine and split the samples in the field to ensure a representative aliquot. Another option for water samples is a laboratory composite for separately collected grab samples.

4.2 SAMPLE PRESERVATION

Sample preservation should be performed in the field immediately after sample collection and preparation. In many cases where pH control or additions of reagents are required, separate bottles and chemical preservatives may be supplied in the laboratory. In other cases the reagents or preservatives may be placed in the sample bottle prior to delivery to the site. Samples collected for organic and inorganic parameters are preserved by storing at 4° C, using natural ice.

Concentrated acids, bases, and other chemicals used to preserve samples cannot be shipped by air. They should be shipped, before sampling begins, to the site or a location near the site, by ground transportation if the site is not local to the consultant's office.

4.3 SAMPLE STORAGE

Samples should be stored in a container nonreactive with the sample or any parameter that is being analyzed for. Generally, containers are made of plastic, glass, or Teflon. In general, samples collected for metals and general water quality parameters are stored in plastic bottles. Samples collected for organic analysis are routinely placed in glass bottles. Soil samples are generally placed in glass jars with Teflon or plastic lid liners. EPA SW-846 Table 1 details the required containers, preservation techniques, and holding times as required.

In most cases, bottles will be supplied by the laboratory conducting the analyses. It will be the responsibility of the sampler to inform the laboratory staff exactly which analyses will be conducted so the lab can supply the proper amount of appropriate bottles. The filled sample bottles must be stored in a cooler with ice.

4.4 EQUIPMENT AND MATERIAL DECONTAMINATION

All equipment and materials used for the collection, preparation, preservation, and storage of environmental or hazardous substance samples must be cleaned prior to its use and after each subsequent use. Unless the equipment and materials being used are disposable, dedicated to the sampling location, or of sufficient number so as not to be reused during any one sampling trip, decontamination must be conducted in the field.

The equipment needed for cleaning or decontamination is dependent upon the materials and equipment to be cleaned. If relatively small items are to be cleaned in the field, several small buckets and small containers of reagents or wash liquids are adequate. However, if major items such as large pumps are to be decontaminated, it may be necessary to transport large wash basins and larger volumes of washing solutions. The following is a generalized equipment list to be used during decontamination and cleaning.

1) Detergent, such as Alconox.
2) Potable water.
3) Deionized and/or distilled water.
4) Hexane, to remove petroleum products.
5) Storage vessels to transport large volumes of water to the site. Plastic carboys that have 5 to 15 gallon capacity and are made with a spigot near the bottom of the tank are recommended. Enough water to handle the needs for the entire day must be supplied. Containers of various sizes are used depending on the sampling program.
6) Methanol.
7) Buckets for washing and rinsing equipment.
8) Paper towels and Chem wipes to remove excess soil or petroleum products before the equipment is decontaminated.

The following procedure will be used to decontaminate the sampling equipment:

1) Rinse with hexane to remove tar or oil, if present.
2) Wash with a detergent and tap water.
3) Rinse with tap water.
4) Rinse with high-purity methanol.
5) Rinse well with distilled and/or deionized water.
6) Use equipment immediately or wrap in aluminum foil for temporary storage.

5.0 SAMPLE PACKAGING, SHIPPING, AND CHAIN-OF-CUSTODY PROCEDURES

Once the samples have been collected, prepared, preserved, and appropriately stored, they must be packaged and shipped. In addition, from the time of sample collection until analyses have been completed, chain-of-custody procedures must be followed to ensure the proper handling of the samples. This section outlines procedures for the packing and shipping of environmental samples and general chain-of-custody procedures.

5.1 PACKAGING AND SHIPPING PROCEDURES FOR ENVIRONMENTAL SAMPLES

All sample containers must be placed in a sturdy, insulated shipping container. A metal or plastic picnic cooler is recommended. The following is an outline of the procedures to be followed.

1) Using fiberglass tape, secure the drain plug at the bottom of the cooler to ensure that water from sample container breakage or ice melt does not leak from the cooler.
2) Line the bottom of the cooler with a layer of cushioning absorbent material such as vermiculite.
3) Pack sample bottles in the cooler. Check screw caps for tightness and mark sample volume level on the outside of large containers.
4) Use pieces of carved-out plastic foam to keep large glass containers in place and to prevent breakage.
5) Pack small containers, such as 40 milliliter vials, in small plastic sandwich bags. When shipping these with large containers, it is necessary to prevent larger containers from shifting, which might break the smaller containers.
6) Pack cushioning material, such as vermiculite or bubble pack, between sample containers.
7) Pack absorbent material around plastic bottles in case of breakage or leaks.
8) Pack ice, sealed in plastic bags, on top of the samples in the cooler when the samples must be kept cold.
9) Seal the chain-of-custody form in a plastic bag and attach it to the inside of the cooler lid.
10) Close the lid of the cooler; be sure it is tightly fastened.
11) Use fiberglass tape to seal the container between the lid and the cooler. Wrap the tape vertically around the cooler, two wraps each on the long and short dimensions.
12) Attach the following information to the outside of the cooler: name and address of the receiving laboratory with return address, arrows indicating "This End Up" on all four sides, and "This End Up" label on the top of the lid.
13) Use additional labels such as "Fragile" or "Liquid in Glass" when necessary.
14) When the cooler is not equipped with a padlock, apply a signed custody seal and place it between the lid and body of the cooler.

Samples package in this way can be shipped by commercial air cargo transporter. Staff should be prepared to open and re-seal the cooler for inspection when required. Be aware that some commercial carriers have limits as to the number of pounds per item that can be shipped. Inform the laboratory of the containers' Bill of Lading numbers.

5.2 CHAIN-OF-CUSTODY PROCEDURES

Each sample must be labeled using waterproof ink and sealed immediately after it is collected. Labels should be filled out before collection to minimize handling of sample container.

Labels and tags must be firmly affixed to the sample containers. Be sure that the container is dry enough for a gummed label to be securely attached. Tags attached by string are acceptable when gummed labels are not applicable.

Sampling information will be recorded in the field on the Sampling Record form.

Written chain-of-custody procedures must be available and followed whenever samples are collected, transferred, stored, analyzed, or destroyed. The primary objective of these procedures is to create accurate written records that can be used to trace the possession and handling of the sample from the moment of its collection through analysis.

A sample is defined as being in someone's "custody" if:

1) it is in one's actual possession, or
2) it is one's view, after being in one's physical possession, or
3) it is in one's physical possessions and then locked up so that no one can tamper with it, or
4) it is kept in a secured area, restricted to authorized personnel only.

The number of persons involved in collecting and handling samples will be kept at a minimum.

The chain-of-custody record will be completed at the time each sample is collected.

One member of the sampling team will be appointed Field Custodian. The samples and forms are turned over to the Field Custodian by the team members who collected the samples at the end of each day.

When transferring the samples, the transferee must sign and record the date and time on the chain-of-custody record. Custody transfers made to the Field Custodian should account for each sample, although samples may be transferred as a group. Every person who takes custody must fill in the appropriate section of the chain-of-custody record. To minimize the custody records, the number of custodians in the chain-of-possession should be minimized.

The Field Custodian is responsible for properly packaging and dispatching samples to the appropriate laboratory. This responsibility includes filling out, dating, and signing the appropriate portion of the chain-of-custody record.

All packages sent to the laboratory should be accompanied by the chain-of-custody record and other pertinent forms. A copy of these forms should be retained by the originating office (either carbon copy or photocopy). Mailed packages can be registered with return receipt requested. For packages sent by common carrier, receipts should be retained as part of the permanent chain-of-custody documentation.