November 11th 2014:

Final Report to the Teton County Commissioneers: Rehabilitation of the Evapotranspiration Final Cover at the Teton County Municipal Solid Waste Landfill

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The Agreement

The Agreement between RegTech, Inc. (Contractor) and the Teton County Idaho Commissioners (County) is to evaluate, through records review, evidence that the Teton County landfill cover has failed to prevent water from percolating through the waste material. If that proves to be the case, the Contractor will investigate possible corrective measures to overcome current noncompliance claims with Idaho Solid Waste Regulations.

Contractor Work

Task 1. Investigate records, including design as-built maps and reports and other applicable correspondence to determine if evidence exists that liquid is migrating through the Evapotranspiration Final Cover (ET) cover, encountering waste, and exiting the landfill. Review applicable documentation, visit the site and discuss questions with landfill operator.

Task 2. Evaluate additional alternatives for bringing the ET cover into compliance with IDAPA Title 39 chapter 74 Idaho Solid Waste Facilities Act and 40 CFR 258. This work may include reviewing landfill cover performance monitoring requirements, record review of landfill operations records, and, inspection and material certification procedures and records.

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Evapotranspiration in Final Landfill Covers

Final landfill covers, and in this case an evapotranspiration (ET) final cover, must minimize infiltration of moisture through solid waste material to prevent unacceptable human and environmental exposure from contaminants derived from the waste (IDAPA Title 39, Chapter 74[1] and 40 CFR Part 258[2]). A landfill closed with an ET cover depends upon the following mechanisms to impede, store, and remove moisture (rain and snow):

1. Transpiration – the transfer of moisture from the soil column to the atmosphere by plants. Transpiration is a **dynamic** process dependent on the plant root depth, climate (plant growing season), plant and root density, and leaf area index. Transpiration removes the largest amount of moisture from the soil column in an ET cover. The vegetative cover may take years to be fully established.
2. Soil Water Storage – the ability of a subsurface material to absorb and retain moisture in the pore structure. This is a **static** design/construction parameter of the ET cover. Adequate material sizing and proper placement during construction is critical to develop adequate water storage capacity in an ET cover.
3. Evaporation – the movement of water from the soil column to the atmosphere by bare soil evaporation. Evaporation is a **variable** property of an ET cover. Variability means evaporation is higher during extended periods of warm weather; more water is typically transferred from the soil profile to the atmosphere during warm weather.

Solid waste material disposed of in a landfill contains potential contaminants. During landfill operation daily cover is placed over solid waste material to minimize distribution of dust. It is likely that a minor amount of liquids are present in municipal waste deposited in a landfill. Regardless of the care, liquids (water) exist in active landfills; however, water-holding capacity within the waste, the daily cover material and the natural material below the bottom of the landfill can prevent contaminants from reaching the groundwater and contaminating it to unacceptable levels. To ensure that an unlined municipal solid waste landfill is preventing water from leaching through waste material and into the underlying aquifer, monitoring must be conducted.

Cover systems are constructed in various layers vertically, but laterally they must be homogeneous and continuous to prevent the development of preferential pathways that allow liquid to migrate past the ET cover. Therefore, it is undesirable to construct a landfill cover with any vertical penetrations.

Typically the performance of a landfill system is monitored using the environment below the landfill and physical inspections of the surface of the cover. Groundwater monitoring evaluates the performance of the *closed landfill system*; physical inspections monitor the horizontal and vertical integrity of the *landfill cover*. Should either yield evidence that the landfill system is not performing as predicted, additional and sometimes intrusive investigations of the cover material and construction are necessary.

Teton County Landfill

The Teton County Landfill is an inactive municipal solid waste landfill being closed according to a state authority defined in Idaho Administrative Procedures Act (IDAPA) Title 39 Chapter 74 Idaho Solid Waste Facilities Act equivalent to (40 CFR (Code of Federal Regulations) Part 258

[1] IDAPA Title 39, Chapter 74 Idaho Solid Waste Facilities Act
[2] 40 CFR Part 258 Criteria For Municipal Solid Waste Landfills.

Criteria for Solid Waste Landfill. Closing landfills require a final cover. An ET cover was installed on the Teton County Landfill according to a 2007 Closure Plan[3]. Records of its construction Quality Control[4] and Quality Assurance[5] were not available.

During a visit to the Teton County landfill October 1st – 3rd, RegTech Inc. conducted a walk around review of the landfill, collected records, and conducted interviews with Saul Varela, Landfill Solid Waste Supervisor, John Rice, Hydrologist, Rocky Mountain Environmental; Brent (Husk) Crowther and Kevin Harris, Forsgren Engineering; and the Teton County Assistant to County Commissioners, Dawn Felchle.

Investigation

In early 2010 Teton County staff volunteered information to the Idaho Department of Environmental Quality (IDEQ) regarding liquid exiting the landfill through a discharge pipe within the footprint of the Teton County municipal solid waste landfill (Idaho DEQ Letter dated 5/13/10 to Louis Simonet[6]). The County and IDEQ personnel, pending a subsequent site visit, suspected the liquid of being *leachate*[7].

Task 1: Investigate records, including design as-built maps and reports and other applicable correspondence to determine if evidence exists that liquid is migrating through the ET cover, encountering waste, and exiting the landfill. Review applicable documentation, visit the site and discuss questions with landfill operator.

According to interviews with Saul Varela, Solid Waste Supervisor, a pipe was installed to redirect nuisance water that had been pooling on or near the landfill haul road and fee station while the landfill was actively receiving waste. When the ET cover was constructed in 2007 the pipe was left in its original position. The pipe is not a requirement of Landfill Closure. Since that time the pipe has begun to discharge water to the surface below the landfill cover Figure 1. The characteristics of the pipe−its length, elevation at its upper end, its placement relative to the waste material−are unknown.

Task 1: Result of Investigation

Liquid emanating from a discharge pipe does not in and of itself constitute *leachate*; however, the Pace Analytical laboratory analysis report[8] resulted in the detection of 15 metals and 8 organic parameters from the Appendix 1 landfill constituents (Table 1). Even though these values are low, they indicate the liquid has come in contact with waste constituents within the landfill. Therefore the liquid is considered, and is subsequently treated as, *leachate*.

The origin of the liquid has two possibilities: 1) precipitation (rain or snow), or 2) groundwater coming in contact with waste constituents. The lowest elevation of the discharge pipe collecting liquid from the landfill is reported by Nelsen Engineering[9] to be 6,211.32 ft. The nearest monitoring well is approximately 300 ft east-southeast. The elevation of the land surface at MW-4 is 6,216 ft (approximately 5 ft difference in elevation). From June 4 2012 through June 6 2014 (two years) the highest elevation of the groundwater reported is 6,176.9. At its highest elevation the groundwater was still 34.42 feet below the lowest point of the discharge pipe.

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[3] Teton County Municipal Landfill Closure Plan. Initial submittal January 30, 2007, last revision August 1, 2008.
[4] Construction quality control is an on-going process of measuring and controlling the characteristics of the product that is employed by the manufacturer of materials and by the contractor installing materials at the site.
[5] Construction quality assurance consists of a planned series of observations and tests to ensure that the final product meets project specifications. CQA plans, specifications, observations, and tests are used to provide quantitative criteria with which to accept the final product.
[6] Idaho Department of Environmental Quality Certified Letter to Louis Simonet dated May 13, 2010
[7] IDAPA Title 39, Chapter 74 (27) (27) "Leachate" means a liquid that has passed through or emerged from solid waste and contains soluble, suspended or miscible materials removed from such waste.
[8] Pace Analytical Report June 8, 2010
[9] Nelsen Engineering, Teton County Landfill – ET Cap Investigation – Phase II Report September 11, 2012.

Consequently, we can *exclude groundwater* as a possible source of the water exiting the discharge pipe and assume precipitation is the source. This assumption is supported by personal accounts by landfill personnel that the rate of discharge tends to coincide with rainfall events.

Since the discharged liquid also exhibits characteristics of municipal solid waste, the evidence suggests that in the vicinity of the discharge pipe, the ET cover is not performing properly.

From this single piece of evidence IDEQ issued a Voluntary Consent Order[10] (July 28 2010). As a result Teton County agreed to

1. Develop a remediation plan for the leachate and associated contaminated soils,
2. Investigate the current and future performance of the ET cover throughout the landfill area.

The county also agreed to characterize the liquid and abate the release of liquid from the pipe. A lined pond was constructed to capture the liquid and two samples of standing surface water (Figure 1) were collected and delivered to Pace Analytical for analysis for Appendix 1 Landfill Constituents.

Table 1. Appendix 1 constituents

Metals

Parameter	Value ug/L	Regulatory limit
Antimony	0.67	6
Arsenic	8.3	50
Barium	377	2000
Beryllium	0.76	4
Cadmium	6.3	5
Chromium	21.7	100
Cobalt	6.3	NA
Copper	22.2	1,300
Lead	25.1	15
Nickel	21.7	NA
Selenium	1.2	50
Silver	0.5	100
Thallium	0.28	2
Vanadium	21.5	NA
Zinc	201	5,000

Organics

Parameter	Value ug/L	Regulatory limit ug/L
Acetone	2000	
Butanone (M	3040	
cis-1,2, Dich	16.3	70
Ethylbenzen	17	700
4-methyl-2-p	43.5	
Styrene	5.6	100
Toluene	551	1,000
Xylene	30.7	10,000

Observation

The orientation of the discharge pipe, relative to the waste material in the landfill is unknown. The discharge pipe is not a requirement of Landfill Closure nor does it offer any valuable insight to the performance of the landfill or its cover in the future. It has provided speculative evidence that *leachate* is being generated from the landfill area around the discharge pipe.

Recommendation

During upcoming rehabilitation of the ET landfill cover, remove the discharge pipe and document its dimensions, attitude and location.

[10] Idaho Department of Environmental Quality Voluntary Consent order Idaho Code 39-108 Received by the county July 28th 2010.

Task 2: Alternatives to Achieve Compliance

Task 2. Evaluate additional alternatives for bringing the ET cover of the landfill into compliance with IDAPA Title 39 chapter 74 Idaho Solid Waste Facilities Act and 40 CFR 258. This work may include reviewing landfill cover performance monitoring requirements, reviewing landfill operation records, and reviewing inspection and material certification procedures and records.

Based on its investigation, RegTech Inc. presents a number of recommendations relative to four (4) different aspects of the ET cover:

1. **Material Testing and Construction**
2. **Certification of Construction**
3. **Long-term Inspection and Maintenance**
4. **Cover Performance Monitoring**

The recommendations address issues resulting from past activities and limit future liabilities.

1. Material Testing and Construction

ET cover systems rely on transpiration, soil water storage, and evaporation. Soil properties of the cover system provide the ET cover the ability to trap and store the water until the plants can capture and transpire the water or the water can evaporate to the atmosphere.

ET cover performance is dependent on selecting the most beneficial material properties. Construction modifies these material properties to provide a growth medium for plants and a medium with optimal water holding capacity.

Design drawings and construction specifications describe specific physical and chemical property requirements for the various natural and manmade materials to be used in the cover. Improper material will not provide an adequate growth medium in the soil cover layer to sustain an optimal vegetative cover (transpiration). Additionally, lax control of construction details may diminish the water holding capacity (soil water storage) within the ET cover. Suitability of the materials and construction proposed to be used in an ET final landfill cover must be confirmed by physical tests in the construction quality assurance (CQA) plan.

There are general do's and don't regarding construction practices.

- Do adhere to the specification.
  - Don't deviate from specifications without the approval of the Site Design Engineer
- Do loosen over compacted material
  - Don't over compact material
- Do use light, tracked (low ground pressure) construction equipment
  - Don't use heavy wheeled equipment
- Do allow soil to dry below optimum moisture content before being placed
  - Don't over moisten soil during placement
- Do place fill in thick cushioning lifts
  - Don't place fill in thin lifts
- Do place haul roads and stockpiles elsewhere
  - Don't create haul roads across or material stockpiles on the cover.

A construction quality assurance (CQA) plan requires specific tests and testing frequencies on materials to measure those specific material properties for comparison with the numeric requirements given in the design and specifications (ITRC 2003[11]).

[11] ITRC 2003 Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Covers. December 2003. ITRC guidance is the result of numerous state environmental agencies, in this case 11, and other expertise, in this case the University of Wisconsin Madison, Desert Research institute, University of Colorado, 11 consulting companies, USEPA, Air Force, and the Department of Energy.

The 2007 Teton County Municipal Landfill Closure Plan, Section 6.0 says "one sieve analysis shall be taken for each 10,000 cubic yards of final cover material placed. The sample shall be taken at the source to prevent out-of-spec material from being placed in the final cover." *During this investigation no records were available to document these tests were performed or that the material met design specifications.*

In response to the IDEQ July 28 2010 Notice of Violation, Nelsen Engineering reported (October 3 2012 Nelson Engineering Report ET Cover Investigation – Phase II[12]) "even though the field investigation concluded that the final cover had been placed in adequate thickness and exhibited a degree of homogeneity in placement and texture, the laboratory tests indicate the water holding capacity is less than design called for and permeability is lower that design called for." In the same report Nelson Engineering reported, "as a result of the information collected and evaluated from the field investigation, construction of the landfill cover appears generally uniform with regard to thickness, soil densities, and soil textures. However the as-built water holding capacity of 0.085 and permeability of 1.24 x 10-5 cm/sec in the cover samples do not compare well with the design value's obtained and used in 2007, and the cumulative effect is that the final cover is not performing as projected."

The recent Preliminary Engineering Report (PER) by Forsgren Engineering Teton County, Idaho Landfill ET Cover Rehabilitation (Table 7) 6/18/14[13] recommends a soil screening test be conducted at the rate of 1 soil screening test per 1,000 Yds^3. IDEQ has requested 1 soil-screening test per 100 yds^3.

Observation 1A

IDEQ personnel requests for additional testing, although at a seemingly unreasonably high rate, will establish greater confidence with them that the material will be adequate to meet the design requirements of this ET cover. Lowering uncertainty due to material properties will also reduce the long-term risk to the county that the cover may fail.

Recommendation 1A

Conduct soil testing every 100 yds^3. This satisfies IDEQ and will raise their confidence in the capability of the ET cover system. It also increases the county's certainty in the material used to construct the ET cover, thereby reducing the risk of future liabilities.

Observation 1B

The 2007 Closure Plan lacked documentation of construction techniques, allowable equipment, and as-built documentation. The current PER contains a detailed CQA plan; however, it does not clearly define acceptable equipment, operation of that equipment, and limitations to the use of that equipment.

Recommendation 1B

Revise or provide an addendum to the 6/18/14 PER clarifying the definitions of acceptable equipment, operation of that equipment, and limitations to the use of equipment.

2. Certification of Construction

The 6/18/14 PER (Appendix D) includes a Construction Quality Assurance (CQA) personnel hierarchy and structure. The hierarchy and structure lists the "parties" involved in CQA activities, including individual affiliation, duties, and responsibilities respective to the CQA of

[12] Teton County Landfill – ET Cap investigation-Phase II Report October 3rd 2012 by Nelson Engineering.
[13] Teton County, Idaho Landfill ET Cap Rehabilitation – Preliminary Engineering Report (PER) June 18th 2014.

the ET cover.

Observation

The 2007 Closure Plan did not formally address the Certification of Construction and no as-built drawings or other documentation to assure construction was within specified design requirements are available. However, the 6/18/14 PER does include a CQA featuring Table 6-*Project Reporting Summary*, Table 7-*Conformance Test Requirements for Stockpiled Material*, and Appendix D-*Quality Assurance Plan for Engineered Landfill Cover*, Teton County Landfill Idaho.

Recommendation

1. An independent professional engineer or scientist, licensed in the state of Idaho should be retained and held responsible as the Project Manager specifically and solely for the Final Certification and Summary report of the final landfill cover (PER, Appendix D, Section 5.8.6).
2. Forms, checklists, and change approval forms should be developed for all reporting requirements in Table 6 and 7. These documents should be collected and signed by the licensed engineer or scientist and stored in a secure and retrievable fashion. This improves consistency in reporting and certainty in final construction to the County and IDEQ. (PER Appendix D, Section 5.8.7).

If problems are encountered with the landfill, these records will help guide the initial investigation of the problem.

3. Long Term Inspection and Maintenance

An ET cover depends on thriving vegetation and the lateral and vertical continuity of the properly constructed cover material. Periodic inspections of an ET cover can reveal surface expression and cover irregularities such as subsidence[14] due to degrading waste, animal burrows that can create preferential flow pathways, poor vegetative cover, pooling or ponding water, erosion or other potential intrusion into the landfill cover. Documentation of changes encountered during these inspections can help direct follow-up investigations to evaluate and isolate potential problems with the landfill cover system. Early detection, troubleshooting, and maintenance can avoid costly rehabilitation or remediation.

Observation

As noted earlier, records of the 2007 final construction of the landfill, material tests, and post construction inspections were not available.

Recommendation

Upon Final Certification of Construction, a long-term inspection and maintenance schedule should be developed, resources provided, and inspections conducted throughout the life of the post-closure care period. At a minimum, the inspection and maintenance program should include the following:

- Cover integrity monitoring, to include visual inspections and observations for cover vegetation, erosion, animal burrows or trails, subsidence and settling or other intrusions into the ET cover or area.

[14] Subsidence – To sink to a lower level.

- Written documentation including photos, drawings, and signatures. All documentation should be maintained throughout the life of the landfill Post Closure Care period.

4. Cover Performance Monitoring

An ET cover depends on three physical components to prevent the infiltration of moisture: transpiration, soil water storage, and evaporation. As described earlier, performance of these parameters depend on the ET cover material and construction. Methods to monitor the moisture flux[15], a hydraulic property of an ET cover, are fraught with uncertainty. ITRC 2003 states, "As regulatory agencies become more confidant that Alternative Final Covers (AFC) [Evapotranspiration cover] are capable of providing an acceptable level of protection to the environment, the installation of flux monitoring devices may no longer be required. At this writing (2003) there is not an industry-wide acceptable level for flux through an AFC and no commonly agreed upon method of demonstrating performance."

ITRC goes on to say, "If EPA promulgates regulations or publishes guidance regarding flux rates, those criteria should be considered in the design decision process." EPA has not promulgated flux rates as a performance metric for ET covers. ITRC 2003 further reports "A complicating factor is that flux-monitoring devices contain uncertainty inherent in their operation. Simple maintenance can cause variability in the quality of data they collect."

Observations

Charles Johnson, Manager of the Solid Waste Section of the State of Colorado Department of Health and Environment, and Michael Wocknick, P.E, Senior Waste Management Engineer for the California Integrated Waste Management Board, report that their authority (the State of Colorado and the California Regional Water Board) *do not* use flux monitoring devices (lysimeters or moisture monitoring sensors) to evaluate the performance of an ET cover system. Instead, they rely on material specification tests and documented quality construction techniques to assure performance of the landfill during the Post Closure Care period, including the cover system. Construction quality assurance provides them greater confidence and less risk of failure than infiltration monitoring methods.

Lysimeters collect data on the deep flux through a given area (e.g. 1.0 m x 1.0 meter or 10.0 m x 10.0 meters or a drain gage lysimeter) of a soil profile. This is a gross value of flux through a soil column. Detection of this moisture front does not offer any indication that any one, or all, of the components of the cover system (transpiration, water holding capacity, or evaporation) are performing properly or improperly. Lysimeter data are not capable of determining if the vegetative cover is inadequate, if the material is inadequate, if the cover is constructed improperly, or if the size fraction of the cover material is allowing more than modeled infiltration. Lysimeter data is not a reliable hydraulic test to evaluate the intrinsic permeability (a physical parameter and regulatory metric) of the cover material.

Multiple soil moisture probes, on the other hand, can be installed within the ET cover to measure flux in the vertical profile of the ET cover. They may even help identify what part of the landfill cover is failing before it reaches the waste material. These probes, however, are notorious for failure and often require routine maintenance. Soil moisture probes are better used as an investigative tool when walk through inspections reveal cover integrity may be jeopardized from settling, erosion, burrowing animals or other intrusions.

[15] Flux means flow rate per unit area.

While lysimeters can provide data, it is data that does not provide any indication of what part of the system is weak; while soil moisture probes can indicate weaknesses in the landfill cover, they are not reliable over the long term.

ITRC 2003 points out that "data from flux monitoring devices alone may not be sufficient to trigger corrective action on an AFC, but may trigger further actions, such as increased monitoring or evaluation of the system."

In the letter dated February 21 2014 to Jay Mazalewski, PE from Erick Neher, Regional Administrator Idaho Falls Regional IDEQ Office:

> *"On-going cover Monitoring – Future cover performance is critical to the Department's approval of the proposed alternative. At a minimum, monitoring should include geophysical techniques, lysimeters, (an/or appropriate in situ methods) and calculated and actual infiltration and leachate measurements which will be compared to regulatory criteria. These lines of evidence should be tied to the modeled expectation for the cover to verify the efficiency of the remedial action."*

Idaho Closure Rules (Title 39, chapter 74) 39-7415 Standard for Closure requires an ET cover system maintain an intrinsic permeability of 1 x 10^{-3} cm/sec and a minimum thickness of 24 inches. The Federal regulations 40 CFR 258.60 (a)(20) requires a minimum thickness of 18 inches plus 6 inches of a soil layer supporting the vegetative cover in an unlined landfill. Intrinsic permeability is an intensive property that is a function of the material and material structure only (and not the fluid). Intrinsic permeability should not be confused with hydraulic conductivity, particularly in unsaturated conditions. No regulatory criteria for measurement of flux (flow rate) in an ET covers exist. Physical characteristics of the subsurface can only be measured accurately on a physical sample. Appendix D of the CQA Plan Rehabilitation Report describes the testing performed prior to and during construction to maintain the physical specification of the landfill cover.

Other states are not installing in situ cover performance monitors. They rely on testing against material specification and documentation of construction quality control. Following construction completion they do not monitor cover systems, they monitor landfill system performance through groundwater monitoring.

Recommendation

Reject flux monitoring in the ET cover. The data reliability is poor and there is no metric to evaluate the landfill performance. Data of this sort may increase the risk of future liability similar to that experienced from the liquid being discharged from the discharge pipe currently in the cover system. Emphasize construction quality controls and documentation by an independent licensed professional engineer or scientist.

Figure 1. Areal view (Google Earth image) of the Teton County Municipal Solid Waste Landfill and location of the discharge pipe (to the right). On the left Photos (Courtesy of Teton County) of the location of the discharge pipe and surface water discharge.