

# Preliminary Remedial Alternative Analysis

**BOUNDARY VENTURES, INC., KENETH OWENS PROPERTY  
FFACILITY, PERMIT NO.L STF-010  
COLORADO COUNTY, TEXAS**

Issue Date: August 30, 2019

Terracon Project No. 96187C01



**Prepared for:**

Railroad Commission of Texas  
Oil and Gas Division  
Austin, Texas

**Prepared by:**

Terracon Consultants, Inc.  
Austin, Texas

Offices Nationwide  
Employee-Owned

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**Terracon**

August 30, 2019

Mr. Michael Leckie  
Railroad Commission of Texas  
Site Remediation Division  
P.O. Box 12967  
Austin, Texas 78711-2967

Telephone: 512-463-6417  
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Re: Preliminary Remedial Alternative Analysis Report  
Boundary Ventures, Inc., Kenneth Owens Property Facility, Permit No. STF-010  
Colorado County, Texas  
Terracon Project No. 96187C01

Dear Mr. Leckie:

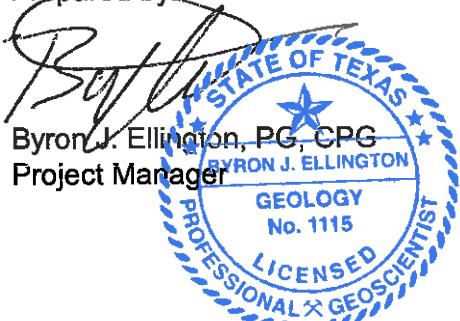
Terracon Consultants, Inc. (Terracon) is pleased to provide the enclosed Preliminary Remedial Alternative Analysis (Preliminary AA) Report, prepared for the referenced property. The Preliminary AA was completed in general accordance with Railroad Commission of Texas (RRC) Requisition Number 455-18-8654.

We appreciate the opportunity to perform these services for you. Please do not hesitate to contact either of the undersigned if you have questions regarding this project.

Sincerely,

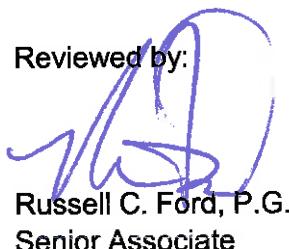
**TERRACON CONSULTANTS, INC.**

Prepared by:



Byron J. Ellington, PG, CPG  
Project Manager

Reviewed by:



Enclosure

## TABLE OF CONTENTS

<b>TERRACON CONSULTANTS, INC.</b> .....	<b>II</b>
<b>1.0 INTRODUCTION .....</b>	<b>1</b>
<b>2.0 DESCRIPTION OF ALTERNATIVES .....</b>	<b>2</b>
<b>3.0 SUMMARY .....</b>	<b>8</b>

## LIST OF APPENDICES

- Appendix A: Exhibit 1 - General Location and Topographic Map  
Exhibit 2 – Area of Concern Map  
Exhibit 3 – Alternative 2 17 Acre Above Grade Landfill, Engineering Control  
Exhibit 4 – Alternative 4 Land Treatment Area  
Exhibit 5 – Alternative 6 50 Acre Above Grade Landfill, Engineering Control
- Appendix B Table 1 – Preliminary Remedial Alternative Analysis Subjective Score  
Table 2 - Preliminary Remedial Alternative Analysis Cost Projections  
Table 3 – Preliminary Remedial Alternative Analysis Intermediate Cost Calculations  
Table 4 – Estimated Volumes of Impacted Soils and Waste
- Appendix C: Supporting Calculations



## Preliminary Remedial Alternative Analysis Report

**Boundary Ventures, Inc.**

**Kenneth Owens Property Facility**

**Colorado County, Texas**

Terracon Project No. 96187C01

August 30, 2019

### 1.0 INTRODUCTION

#### 1.1 Site Description

<b>Site Name</b>	Boundary Ventures, Inc., Kenneth Owens Property Facility, Permit No. STF-010.
<b>Site Location/Address</b>	Approximate Latitude, Longitude: 29.549535, -96.454857, Southwest Corner of State Highway 71 and Alternate State Highway 90, Altair (Colorado County), Texas
<b>Site Improvements/Waste/Impacts</b>	Former Cuttings Landfarm and Road Base Recycling Facility - buildings, tank batteries, frac tanks, pug mills, chemical totes, loading / offloading pads in various states of disrepair, unlined earthen pit, approximately 150 acres.

The Boundary Ventures, Inc., Kenneth Owens Property Facility (site), is located approximately 1.5 miles south of the town of Altair, Colorado County, Texas. The site location is depicted on Exhibit 1 with site details found on Exhibits 2 through 5.

According to the Railroad Commission of Texas (RRC) the site has been the subject of RRC enforcement for many years and has failed to properly reduce its inventory of oil field waste (mainly impacted drill cuttings), finished recycled product, or to properly address environmental concerns. According to the last available issuance of the facilities permit made available to Terracon (October 21, 2005), the facility was authorized to receive, store, handle, treat, and dispose of certain nonhazardous oil and gas waste. According to the permit, the facility also was authorized to landfarm water-based drilling mud and cuttings and allowed to manufacture road base from cuttings.

## Preliminary Remedial Alternative Analysis Report

Boundary Ventures, Kenneth Owens Property Facility ■ Colorado County, Texas

August 30, 2019 ■ Terracon Project No. 96187C01

### 1.2 Standard of Care

Terracon's services were performed in a manner consistent with generally accepted practices of the profession undertaken in similar studies in the same geographical area during the same time period. Terracon makes no warranties, either express or implied, regarding the findings, conclusions or recommendations. Please note that Terracon does not warrant the work of laboratories, regulatory agencies or other third parties supplying information used in the preparation of the report. These services were performed in accordance with the scope of work agreed with you, our client, as reflected in our proposal and were not restricted by ASTM E1903-97.

### 1.3 Additional Scope Limitations

Findings, conclusions and recommendations resulting from these services are based upon information derived from the on-site activities and other services performed under this scope of work; such information is subject to change over time. Certain indicators of the presence of hazardous substances, petroleum products, or other constituents may have been latent, inaccessible, unobservable, non-detectable or not present during these services, and we cannot represent that the site contains no hazardous substances, toxic materials, petroleum products, or other latent conditions beyond those identified during this investigation. Subsurface conditions may vary from those encountered at specific borings or wells or during other surveys, tests, assessments, investigations or exploratory services; the data, interpretations, findings, and our recommendations are based solely upon data obtained at the time and within the scope of these services.

### 1.4 Reliance

This report has been prepared for the exclusive use and reliance of the RRC. Use or reliance by any other party is prohibited without the written authorization of the RRC and Terracon Consultants, Inc. Any unauthorized distribution or reuse is at the client's sole risk. Notwithstanding the foregoing, reliance by authorized parties will be subject to the terms, conditions and limitations stated in the work order scope, SIR, and Terracon's Terms and Conditions. The limitation of liability defined in the terms and conditions is the aggregate limit of Terracon's liability to the client and all relying parties unless otherwise agreed in writing.

## 2.0 DESCRIPTION OF ALTERNATIVES

This preliminary remedial alternative analysis (Preliminary AA) was authorized as Task 8 of Terracon's January 17, 2019 proposed scope of work. Although the Preliminary AA is a stand-alone document, it relies to the data and analysis compiled in Terracon's *Site Investigation Report* (dated April 22, 2019), Terracon's *Volume of Impacted Soils Based on Railroad Commission of Texas Jurisdictional Lines* (dated August 5, 2019), and Terracon's *Waste Characterization, Select Soil Sample Results, and Other Observations* (dated July 30, 2019).

## Preliminary Remedial Alternative Analysis Report

Boundary Ventures, Kenneth Owens Property Facility ■ Colorado County, Texas

August 30, 2019 ■ Terracon Project No. 96187C01

The overall goal of the Preliminary AA is to frame a defensible path toward remedy selection, cleanup, and closure of the site while providing an order of magnitude, preliminary cost estimate. The remedial alternatives presented are off-the shelf alternatives known to reduce risk to human health and the environment and which can be safely implemented (e.g. reduce waste contact, etc.). The estimated costs presented as part of the Preliminary AA are to be considered “rough order of magnitude” only and are not appropriate for, and should not be represented as, an engineering level cost estimate for bidding purposes.

The alternatives evaluated are not presented in any order of preference. The six alternatives evaluated are presented below.

### Each of the five alternatives include:

- Site fencing will be repaired and maintained to deter trespassers.
- Four additional groundwater monitoring wells installed to fill groundwater data gaps.
- Groundwater monitoring once or twice per year.
- All wells gauged each sampling event.
- Six wells sampled plus duplicates and QC samples each event.
- One consolidated Groundwater Monitoring Report each year.

### Alternative 1, No Action Except Groundwater Monitoring:

Alternative 1 anticipates the monitoring of groundwater for 30 years.

- Groundwater will be monitored twice per year for years 1 through 5 and then once per year for years 6 through 30.
- Well plug and abandonment at the end of 30 years is not included.

### Alternative 2, Above Grade Landfill, Waste Consolidation, Engineered Cap

Alternative 2 is a partial remedy of waste/soils focused on gross contamination which will be encapsulated in an on-site, above grade landfill. Maintenance of the landfill and the monitoring of groundwater for 30 years is anticipated. Complying with the RRC's environmental permit requirements, guidance, and other appropriate or relevant requirements is also anticipated (e.g. 16TAC.3.8 and related, etc.).

- Landfill with engineered cap construction over and around the waste pile (unprocessed

roadbase) at AOC 1 (205,000 cubic yards-CY).

- Include additional 100,000 CY of hotspot waste from other areas of the site. Hotspot waste are generally thought of as more grossly contaminated waste which may be contributing to the groundwater contaminant plume or exceeding in concentration a direct exposure cleanup value.
- A truncated pyramid shaped landfill with a base of 17 acres and height of 21 feet could accommodate the identified waste. A theoretical footprint is shown in Exhibit 3.
- Relocate equipment and tanks as necessary.
- Address waste/soil data gaps as necessary.
- Fill all or some below grade excavations created while removing waste with imported fill or fill sourced on-site.
- Waste beneath the landfill footprint will be left in place.
- Partial reseed.
- Develop and implement Construction Storm Water Pollution Prevention Plan (SWPPP).
- Obtain and/or substantively comply with other RRC environmental permits, guidance, and other appropriate or relevant requirements.
- Well plug and abandonment at the end of 30 years is not included.

#### Alternative 3, Partial Off-Site Removal

Alternative 3 is a partial remedy of waste/soils focused on gross contamination which will be sent off-site for disposal. Maintenance of an engineering control is not anticipated. Monitoring of groundwater for 30 years is anticipated. Complying with the RRC's environmental permit requirements, guidance, and other appropriate or relevant requirements is also anticipated (e.g. 16TAC.3.8 and related, etc.).

- Off-site disposal of waste pile (unprocessed roadbase) at AOC 1 (205,000 CY).
- Off-site disposal of an additional 100,000 CY of hotspot waste from other areas of the site. Hotspot waste are generally thought of as more grossly contaminated waste which may be contributing to the groundwater contaminant plume or exceeding in concentration a direct exposure cleanup value.
- Fill all or some below grade excavations created while removing waste with imported fill or fill sourced on-site.
- Partial reseed.
- Relocate equipment and tanks as necessary.
- Address waste/soil data gaps as necessary.

## Preliminary Remedial Alternative Analysis Report

Boundary Ventures, Kenneth Owens Property Facility ■ Colorado County, Texas

August 30, 2019 ■ Terracon Project No. 96187C01

- Develop and implement Construction SWPPP.
- Obtain and/or substantively comply with other RRC environmental permits, guidance, and other appropriate or relevant requirements.
- Well plug and abandonment at the end of 30 years is not included.

### Alternative 4, Landtreat All Identified Waste:

Alternative 4 is a complete remedy of identified waste/soils. Alternative 4 is anticipated to take 10 years to implement and will require the constant movement of waste/soils into and out of the landtreatment area, which will be on location. Maintenance of an engineering control past the 10-year implementation schedule is not anticipated. Monitoring of groundwater for 10 years is anticipated. Complying with the RRC's environmental permit requirements, guidance, and other appropriate or relevant requirements is also anticipated (e.g. 16TAC.3.8 and related, etc.).

- Construct landtreatment cell(s) (100+ acres).
- Over 10-year period excavate, transport on-site, stage, mix, and till all identified waste/soils (691,000 CY) until naturally remediated to below action levels.
- Refill excavations with remediated waste/soils.
- Partial reseed.
- Relocate equipment and tanks as necessary.
- Address waste/soil data gaps as necessary.
- Develop and implement Construction SWPPP.
- Obtain and/or substantively comply with other RRC environmental permits, guidance, and other appropriate or relevant requirements.
- Plug and abandonment of monitoring wells and equipment removal at the end of 10 years is included.

### Alternative 5, Off-Site Removal of all Identified Waste

Alternative 5 is a complete remedy of impacted waste/soils that will be sent off-site for disposal. Maintenance of an engineering control is not anticipated. Monitoring of groundwater for up to 7 years is anticipated.

- Off-site disposal of all waste/soils identified as being above action levels. (691,000 CY).
- Fill all or some below grade excavations created while removing waste with imported fill or fill sourced on-site.
- Partial reseed.

**Preliminary Remedial Alternative Analysis Report**

Boundary Ventures, Kenneth Owens Property Facility ■ Colorado County, Texas

August 30, 2019 ■ Terracon Project No. 96187C01

- Relocate equipment and tanks as necessary.
- Address waste/soil data gaps as necessary.
- Develop and implement Construction SWPPP.
- Plug and abandonment of monitoring wells and equipment removal at the end of 7 years is included.

**Alternative 6, Above-Grade Landfill, Waste Consolidation, Engineered Cap**

Alternative 6 is a complete remedy of impacted waste/soils which will be encapsulated in an above grade landfill on location. Maintenance of the landfill and the monitoring of groundwater for 30 years is anticipated. Complying with the RRC's environmental permit requirements, guidance, and other appropriate or relevant requirements is also anticipated (e.g. 16TAC.3.8 and related, etc.).

- Landfill with engineered cap designed to hold all identified waste (691,000 CY).
- A truncated pyramid shaped landfill with a base of 50 acres and height of 21 feet could accommodate the identified waste. A possible footprint is shown in Exhibit 5.
- Fill all or some below grade excavations created while removing waste with imported fill or fill sourced on-site.
- Waste beneath the landfill footprint will be left in place.
- Relocate equipment and tanks as necessary.
- Address waste/soil data gaps as necessary.
- Fill all or some below grade excavations created while removing waste with imported fill or fill sourced on-site.
- Partial reseed.
- Develop and implement Construction Storm Water Pollution Prevention Plan (SWPPP).
- Obtain and/or substantively comply with other RRC environmental permits, guidance, and other appropriate or relevant requirements.
- Well plug and abandonment at the end of 30 years is not included.

Subjective remedy effectiveness scores and estimated costs (in 2019 dollars) for each of the alternatives are presented in Tables 1, 2, and 3. Supporting documentation specific to cleanup estimates and calculations can be found in Appendix C.

## Preliminary Remedial Alternative Analysis Report

Boundary Ventures, Kenneth Owens Property Facility ■ Colorado County, Texas

August 30, 2019 ■ Terracon Project No. 96187C01

Other observations and drivers to the Preliminary AA include:

- As stated above, groundwater appears to be not severely impacted from surface operations, and thus, only future monitoring and some additional groundwater delineation is considered in the Preliminary AA.
- NORM impacts above action levels have not been identified and, therefore, are not considered a remedy driver in the Preliminary AA.
- Volumes of Waste were derived from *Table 1, Estimated Volumes of Impacted Soils and Waste, Boundary Ventures, Subdivided by Jurisdiction, Revised August 2019*.
- Only waste previously determined to be under the jurisdiction of the RRC have been considered.
- During implementation of some, or all, of the remedies would require coordination with the Texas Commission on Environmental Quality whose jurisdictional waste is also at the site.
- COCs requiring remediation are mostly RCRA metals, chlorides, TPH, BTEX. Specific to *Alternative 3 -Partial Off-Site Removal* and *Alternative 5-Off-Site Removal of all Identified Waste* it is anticipated that the impacted material will be disposed of at a facility permitted to receive RCRA Exempt E&P waste (e.g. Cuero Oil Reclamation Washout Facility, Newata Environmental Services, Gonzales Separation Facility, Blackhorn Waste Disposal Facility, etc).
- Specific to *Alternatives 4 -Landtreat All Identified Waste*, it is anticipated that the mixing and tilling remediation process will promote remediation and attenuation of the source material to below action levels.
- The depth of impacted material (see Site Investigation Report), soil borings, and cross-sections) was generally approximated based on field observations, professional judgement of the registered surveyor who completed the aerial survey of material above grade, observations made in the field during the installation of soil borings, and analytical data.
- Tanks, their contents, equipment, and trash on-site were not considered in the Preliminary AA. However, in some cases tanks may contain fluids which will have to be sent off-site for disposal. Tanks, equipment, and trash will be relocated in all cases where they are in the way of the remediation effort. It is also anticipated that the disconnection of electric utilities in a safe manner will be required.
- Only partial reestablishment of vegetation is being considered in Preliminary AA. Situations to consider reestablishment of vegetation include: 1), any situation where the Construction SWPPP deems appropriate such as infiltration ponds or surface filtration buffers near Skull Creek or its tributaries, 2) as part of an engineered cap, or 3) where an excavation is being filled with imported or on-site soil and the reestablishment of vegetation would be relatively easy.

## Preliminary Remedial Alternative Analysis Report

Boundary Ventures, Kenneth Owens Property Facility ■ Colorado County, Texas

August 30, 2019 ■ Terracon Project No. 96187C01

### 3.0 Summary

As expected, Alternative 1 (no action except monitoring) received the highest composite score (14 points-most unfavorable of the Alternatives evaluated) because of its lack of protectiveness, effectiveness, permanence, and toxicity reduction. Alternative 1 did meet expectations in the areas of implementability and relative cost. At \$732,600 over 30 years, Alternative 1 was the lowest overall costs.

Alternative 2 and 3 scored somewhat better than Alternative 1 (receiving composite scores of 12 and 11 points, respectively) but only marginally met expectations in the areas of protectiveness, effectiveness, permanence, and relative costs. Alternative 3 scored better on implantability because of the simple nature of off-site removal. As stated above, Alternatives 2 and 3 were focused remediation of gross waste/soil contamination.

Alternatives 4 and 5 are both complete remedies that will not rely on long-term engineering controls or on long-term monitoring of groundwater. However, to protect receptors from exposure to groundwater, an institutional control is recommended. While Alternative 4 would take longer to implement (estimated 10 years, \$12,000,000), Alternative 5 was by far the most expensive (estimated 7 years, \$54,000,000) of the alternatives considered. Alternative 4 and 5 both scored 9 points.

Alternative 6 is very similar to Alternative 2 and will also rely on an above grade landfill to hold the waste for at least 30 years. However, Alternative 6 assumes that all of the waste will be contained in or below the constructed landfill. Like Alternative 2, long-term maintenance of the landfill and groundwater monitoring will be required.

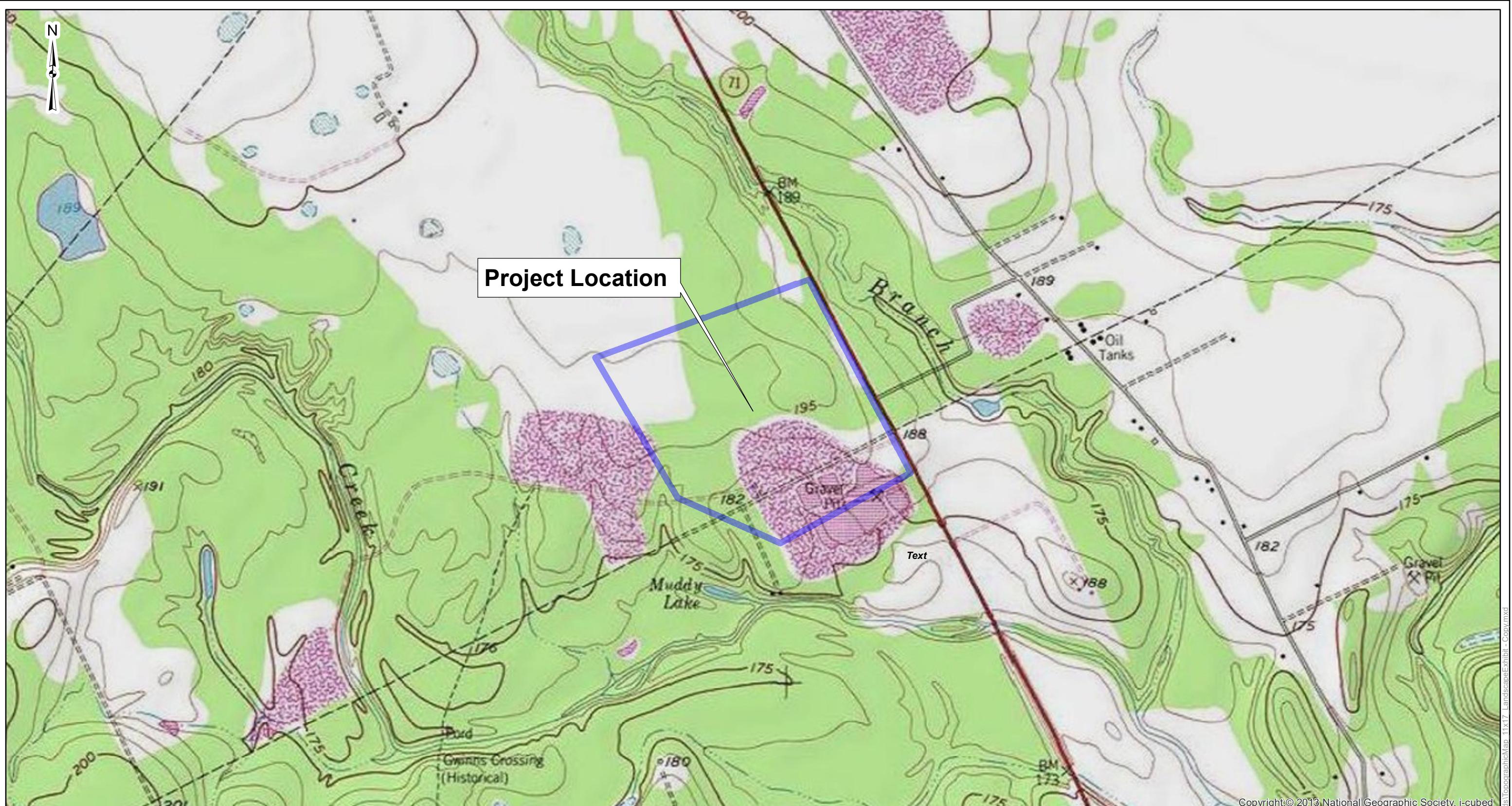
Full details of each of the alternatives can be found on Tables 1, 2, and 3, with supporting information included in Exhibit C.

**Appendix A**

**Exhibits**

**Preliminary Alternative Analysis**

**Boundary Ventures, Inc.  
Kenneth Owens Property Facility  
Colorado County, Texas  
Terracon Project No. 96187C01**



DATA SOURCES:  
ESRI WMS - World Aerial Imagery, OpenStreetMap

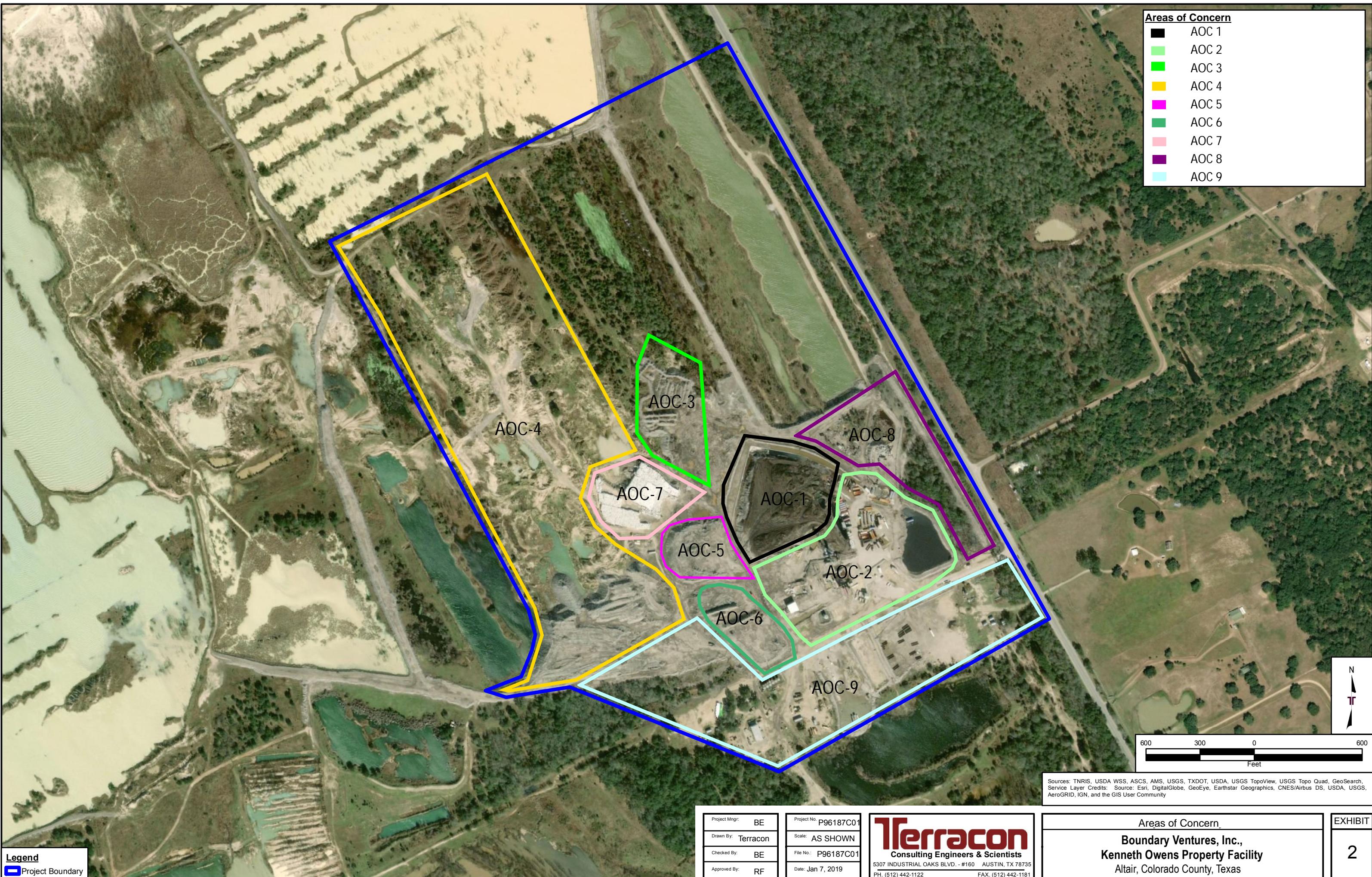
Project No.:	96187C01
Date:	Feb 2019
Drawn By:	AR
Reviewed By:	BE

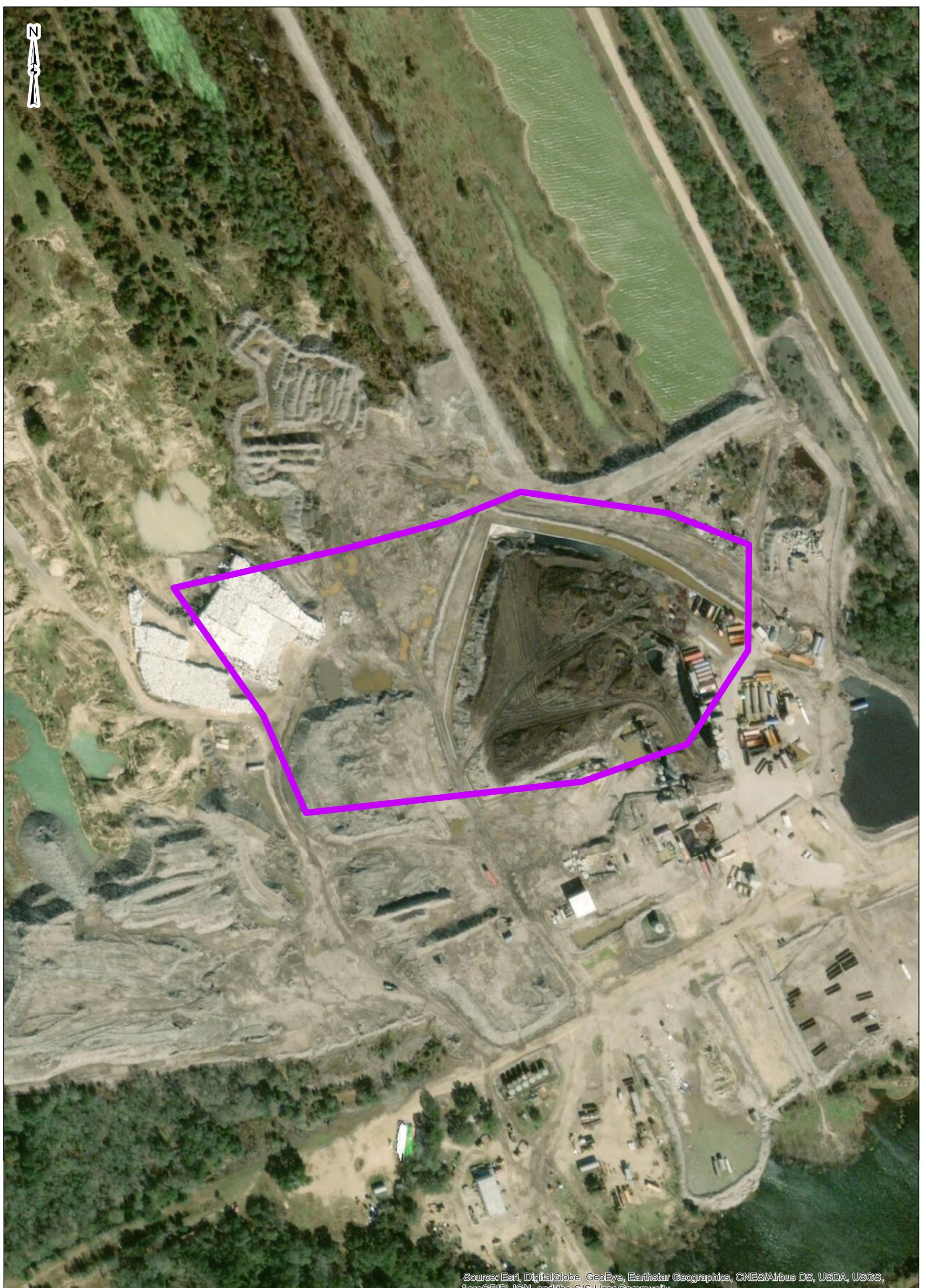
**Terracon**  
5307 Industrial Oaks Boulevard, Suite 160 Austin, TX 78735  
PH. (512) 442-1122 terracon.com

**Topographic Map**  
Boundary Ventures, Inc.  
Kenneth Owens Property Facility  
Altair, Colorado County, Texas

**Exhibit**  
1

Areas of Concern	
AOC 1	
AOC 2	
AOC 3	
AOC 4	
AOC 5	
AOC 6	
AOC 7	
AOC 8	
AOC 9	





DATA SOURCES:

ESRI WMS - World Aerial Imagery, OpenStreetMap

Basemap Image Date: 1/22/2017

The jurisdictional lines represent Terracon's best evaluation based on available information, and do not necessarily reflect a formal determination by RRC staff. Terracon will defer to the MOU Title 16 TAC 3.30 and agency determinations if modifications to jurisdictional boundaries are appropriate and necessary in the future.

0 100 200 400 600 800  
Feet

**Legend**

■ Above Grade Landfill Location Boundary

Project No.:	96187C01
Date:	Aug 2019
Drawn By:	AR
Reviewed By:	BE

**Terracon**  
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**Alternative 2 Above Grade Landfill, Engineering Cap**

Boundary Ventures, Inc.  
Kenneth Owens Property Facility  
Altair, Colorado County, Texas

**Exhibit**

**3**



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

DATA SOURCES:  
ESRI WMS - World Aerial Imagery, OpenStreetMap  
Basemap Image Date: 1/22/2017

The jurisdictional lines represent Terracon's best evaluation based on available information, and do not necessarily reflect a formal determination by RRC staff. Terracon will defer to the MOU Title 16 TAC 3.30 and agency determinations if modifications to jurisdictional boundaries are appropriate and necessary in the future.

0 140 280 560 840 1,120  
Feet

#### Legend

Land Treatment Area Boundary

Project No.:	96187C01
Date:	Aug 2019
Drawn By:	AR
Reviewed By:	BE

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PH. (512) 442-1122 terracon.com

#### Alternative 4 Land Treatment Area

Boundary Ventures, Inc.  
Kenneth Owens Property Facility  
Altair, Colorado County, Texas

#### Exhibit

4



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

DATA SOURCES:  
ESRI WMS - World Aerial Imagery, OpenStreetMap  
Basemap Image Date: 1/22/2017

The jurisdictional lines represent Terracon's best evaluation based on available information, and do not necessarily reflect a formal determination by RRC staff. Terracon will defer to the MOU Title 16 TAC 3.30 and agency determinations if modifications to jurisdictional boundaries are appropriate and necessary in the future.

0 105 210 420 630 840  
Feet

#### Legend

— 50 Acre Above Grade Landfill Location Boundary

Project No.:	96187C01
Date:	Aug 2019
Drawn By:	AR
Reviewed By:	BE



#### Alternative 6 Above Grade Landfill, Engineering Cap

Boundary Ventures, Inc.  
Kenneth Owens Property Facility  
Altair, Colorado County, Texas

#### Exhibit

5

**Appendix B**

**Tables**

**Preliminary Alternative Analysis**

**Boundary Ventures, Inc.  
Kenneth Owens Property Facility  
Colorado County, Texas  
Terracon Project No. 96187C01**

**Table 1**  
**Preliminary Remedial Alternatives Analysis**  
**Subjective Score**

**Boundary Ventures**  
**Colorado County, Texas**  
**August 2019**

	Alternative 1, No Action Except GW Monitoring	Alternative 2, Above Grade Landfill, Waste Consolidation of Some Identified Waste, Engineered Cap	Alternative 3, Partial Off-Site Removal	Alternative 4, Landtreat All Identified Waste	Alternative 5, Off-Site Removal of all Identified Waste	Alternative 6, Above Grade Landfill, Waste Consolidation of All Identified Waste, Engineered Cap
Time to Remediate (years)	30	30	30	10	7	30
Estimated Costs - 0% Discount	\$ 732,600	\$ 7,591,100	\$ 24,201,100	\$ 12,304,600	\$ 54,187,100	\$ 19,075,100
Overall Protectiveness of Human health and the Environment	3	2	2	1	1	1
Long Term Effectiveness and Permanence	3	2	2	1	1	1
Reduction of Toxicity, Mobility, or Volume through Treatment	3	2	2	1	1	1
Short Term Effectiveness	3	2	2	2	1	1
Implementability	1	2	1	2	2	2
Relative Costs	1	2	2	2	3	2
Composite Score	14	12	11	9	9	8

1. Meets Expectations
2. Marginally Meets Expectations
3. Does Not Meet Expectations

**Table 2**  
**Preliminary Remedial Alternatives Analysis**  
**Cost Projections**

**Boundary Ventures  
Colorado County, Texas  
August 2019**

**Table 2**  
**Preliminary Remedial Alternatives Analysis**  
**Cost Projections**

**Boundary Ventures  
Colorado County, Texas  
August 2019**

0% Discount	Number of Years	1	2	3	4	5	6	7	8	9	10
Alternative 4, Landfill All Identified Waste	Cash Flow	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	Roll-up of Major, Alternative Specific Actions, Projected to be Spent in Initial Year(s)	6,660,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
	Install 4 additional MWs <sup>1</sup>	31,000									
	Annual GW Monitoring, 2 samples/year, yearly report <sup>1</sup>	17,000	17,000	17,000	17,000	17,000	10,000	10,000	10,000	10,000	10,000
	Annual Site Security, Fences Repair, etc. <sup>2</sup>	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
	Annual Costs for Periodic Site Mowing, Maintenance Other O&M, etc. <sup>3</sup>	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
	Other Unspecified O&M	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
	Abandonment - Plug 17 Monitoring wells, Demob Equipment										60,000
\$ 12,304,600	Total Cash Flow w/ 10% Contingency	7,455,800	535,700	535,700	535,700	535,700	528,000	528,000	528,000	528,000	594,000

**Table 2**  
**Preliminary Remedial Alternatives Analysis**  
**Cost Projections**

**Boundary Ventures  
Colorado County, Texas  
August 2019**

**Table 3**  
**Preliminary Remedial Alternatives Analysis**  
**Intermediate Cost Calculations**

**Boundary Ventures**  
**Colorado County, Texas**  
**August 2019**

		Alternative 1, No Action Except GW Monitoring	Alternative 2, Above Grade Landfill, Waste Consolidation of Some Identified Waste, Engineered Cap	Alternative 3, Partial Off-Site Removal	Alternative 4, Landtreat All Identified Waste	Alternative 5, Off-Site Removal of all Identified Waste	Alternative 6, Above Grade Landfill, Waste Consolidation of All Identified Waste, Engineered Cap
Costs are carried individually to Table 2 and are Somewhat Alternative Specific	Install 4 additional MWs <sup>1</sup>	31,000	31,000	31,000	31,000	31,000	31,000
	Annual GW Monitoring, 2 samples/year, yearly report. <sup>1</sup>	17,000	17,000	17,000	17,000	17,000	17,000
	Annual Site Security, Fences Repair, etc. <sup>2</sup>	5,000	5,000	5,000	5,000	5,000	5,000
	Annual Costs for Periodic Site Mowing, Maintenance, Other O&M, etc. <sup>3</sup>	5,000	5,000	5,000	5,000	5,000	5,000
	Other Unspecified O&M		30,000	30,000	60,000	60,000	60,000
	Tank and Equipment Relocation (Alternative Specific) <sup>1</sup>	-	50,000	50,000	150,000	150,000	150,000
	Develop and Implement Construction SWPPP <sup>4</sup>		10,000	10,000	100,000	100,000	100,000
	Address Soil Data Gaps, Further Assessment (Alternative Specific) <sup>5</sup>		75,000	75,000	125,000	125,000	125,000
	Bringing Select Below Grade Waste 5 to 15 feet bgs to Surface Staging/Cap Area (Alternatives 2,3 =100 TCY; Alternatives 4,5, 6=407 TCY). Waste under cap footprint left in place. <sup>1</sup>		1,100,000	1,100,000	4,200,000	4,200,000	2,200,000
	Fill Excavation with Imported Fill or Clean Fill Sourced From Site. (Alternatives 2,3 =100 TCY; Alternative 5,6 =200TCY) <sup>1</sup> Not all excavations filled under Alternatives 5, 6.		1,400,000	1,400,000		2,800,000	2,800,000
Costs are subtotalized and carried to Table 2. These costs are mostly Alternative Specific	Moving/Staging of Above Grade Waste (285 TCY) <sup>1</sup>				2,000,000	1,100,000	2,000,000
	Waste Consolidation and Cap Construction <sup>1</sup>		2,700,000				7,500,000
	Off-Site Removal <sup>1</sup>			17,800,000		40,100,000	
	Mix/Till Entire Site 4x Year, Sample <sup>1</sup>				85,000		
	<b>Subtotals</b>	<b>-</b>	<b>5,335,000</b>	<b>20,435,000</b>	<b>6,660,000</b>	<b>48,575,000</b>	<b>14,875,000</b>

Notes:

1. See Appendix A.
2. 2018 Texas Agricultural Custom Rates, Texas A&M AgriLive Extension Service plus inflation and rounded up. Partial new fence, fence repair and maintenance, periodic inspections. Security guard not anticipated.
3. 2018 Texas Agricultural Custom Rates, Texas A&M AgriLive Extension Service. (Mowing around monitoring wells to maintain access. \$12/acre x 30 ac x 2 events/yr)+(Misc.90 hrs/year x \$45/hr). Includes miscellaneous site maintenance.
4. Based on Terracon experience with similar projects. For alternatives 4, 5, and 6, the level of effort has been multiplied by 10 because of the large size and complexity of the Construction SWPPP.
5. **Soil Data Gaps.** Based on Terracon experience with similar projects. For Alternatives 2 and 3, assumes a plume management zone remedy for groundwater and institutional controls to prevent exposure to soils. Alternatives 4 and 5 assumes an plume management zone remedy for groundwater and complete remediation of waste/soils to prevent exposure. Alternative 6 assumes an plume management zone remedy for groundwater and the use of an engineering remedy (landfill and cap) to prevent exposure to waste/soils.
6. **Alternative 4.** Due to the large footprint of the landtreatment area and the reduced thickness of each application of waste, Alternative 4 will require staging and movement of waste over the 10 year lifecycle of the landtreatment remedy. Alternative 4 will also incorporate a mix/till of the entire site 4 times a year. Excavations will not be filled with imported soil but will be filled with remediated soil from the landtreatment area as it becomes available. Therefore, all "Alternative Specific Costs" are applied to Year 1. For years 2 through 10, "Alternative Specific Costs" total is modified by subtracting out the cost of tank relocation, SWPPP, Data Gaps, dividing by 20, and then rounding up to the nearest \$100,000.

**Table 4**  
**Estimated Volumes of Impacted Soils and Waste, Boundary Ventures, Subdivided by Jurisdiction**  
**Altair, Colorado County, Texas**

Revised August 2019

AOC	Preliminary Estimated Volumes Above Grade			Preliminary Estimated Volumes Below Grade			Comments
	Estimated Surveyed Volumes Above Grade and Exceeding Screening Values <sup>5</sup>	RRC Jurisdiction <sup>4</sup>	TCEQ Jurisdiction <sup>4</sup>	Estimated Volumes Below Grade and Exceeding Screening Values <sup>5</sup>	RRC Jurisdiction <sup>4</sup>	TCEQ Jurisdiction <sup>4</sup>	
	cubic yards	cubic yards	cubic yards	cubic yards	cubic yards	cubic yards	
AOC 1	204,994	204,994	0	86,111	86,111	0	Unprocessed drill cuttings/waste, loose pile.
AOC 2	10,697	2,139	8,558	104,184	20,837	83,347	Except for pit berms, roadbase is primarily buried beneath a compacted driving surface. Pit berms made of roadbase. TCEQ jurisdiction waste likely to be spillage or dumping from chemical totes. The water retention pond located in the southeast corner of AOC-2 is assumed to be under TCEQ jurisdiction since it receives run-off from operational areas under TCEQ jurisdiction. TCEQ jurisdiction estimated volumes includes mixing pile but does not include chemical totes, drums or other containers.
AOC 3	11,039	11,039	0	13,891	13,891	0	Roadbase is in loose piles and buried below grade with some driving surfaces.
AOC 4	21,017	21,017	0	43,078	43,078	0	Roadbase is in loose piles and buried beneath grade, Very limited driving surfaces.
AOC 5	22,761	22,761	0	22,992	22,992	0	Roadbase is primarily loose piles and buried beneath grade, Some driving surfaces.
AOC 6	15,988	15,988	0	27,623	27,623	0	Roadbase is in loose piles and buried beneath grade, Limited driving surfaces.
AOC 7 <sup>8</sup>	7,562	1,862	5,700	24,329	24,329	0	Roadbase is in loose piles and buried beneath grade, Some driving surfaces. WG-39 Supersacks, wood pallets, other hazards. An in place volume of 5,700 cubic yards of WG-39 above grade has been estimated (see Table 2). TCEQ jurisdiction waste assumed to be WG-39 material.
AOC 8	6,373	4,142	2,231	9,573	6,222	3,351	Roadbase is in loose piles (including berms of the mixing pit) and buried beneath grade. Limited driving surfaces. TCEQ jurisdiction estimated volumes includes mixing pile but does not include chemical totes, drums or other containers.
AOC 9 West	386	386	0	72	72	0	Roadbase is primarily buried beneath a compacted driving surface.
AOC 9 East	386	0	386	72	0	72	Roadbase (minor amounts, if present) is primarily buried beneath a compacted driving surface. TCEQ jurisdiction likely to be spillage or dumping from chemical tote.
AOC 10South (South of Skull Creek) <sup>6</sup>	0	0	0	90000	90,000	0	Roadbase is primarily buried beneath a compacted driving surface.
AOC 10West (Roadway west of Lease Boundary) <sup>7</sup>	0	0	0	71481	71,481	0	Roadbase is primarily buried beneath a compacted driving surface.
Total Cubic Yards	301,202	284,328	16,875	493,405	406,636	86,769	

Notes:

1. All volume estimates are preliminary in nature and based on initial evaluations of surveyed piles above grade, google earth AOC polygon area measurements, analytical data and depth interval, PID field readings presented in boring logs, lithological breaks presented in boring logs, and cross-sections.

2. A detailed or a mathematical geospatial analysis has not been performed.

3. Volume estimates are not intended to be used as the basis for an engineering level remedial alternative analysis or a remedial alternative cost estimate.

4. Jurisdiction percentages based on jurisdictional line locations provided by RRC personnel, as well as follow-up discussions with the RRC. Considering the format RRC:TCEQ jurisdiction for AOCs 2, 8, 9 West and 9 East the following percentages were applied, respectively. AOC 2-20%:80%; AOC 8-65%:35%; AOC 9 West-100%:0%; and AOC 9 East-0%:100%. All other AOCs assigned an RRC jurisdiction of 100%.

5. From Table 16, Site Investigation Report, Boundary Ventures, Inc., Kenneth Owens Property Facility, Colorado County, Texas, April 22, 2019.

6. AOC 10South. Terracon's February 2019 site investigation did not include this AOC. Volume estimates are derived from a visual surface area measurements and a reasonable worst case depth estimate of impacted material above screening values (486,000 ft<sup>2</sup> surface area x 5 ft deep x 1.0 exceeding screening value x 1yd<sup>3</sup>/27 ft<sup>3</sup>).

7. AOC 10West. Terracon's February 2019 site investigation did not include this AOC. Volume estimates are derived from a visual surface area measurements and a reasonable worst case depth estimate of impacted material above screening values (386,000 ft<sup>2</sup> surface area x 5 ft deep x 1.0 exceeding screening value x 1yd<sup>3</sup>/27 ft<sup>3</sup>).

8. An in place volume of 5,700 cubic yards of WG-39 above grade has been estimated (see Table 2).



## **Appendix C**

### **Supporting Calculations**

#### **Preliminary Alternative Analysis**

**Boundary Ventures, Inc.  
Kenneth Owens Property Facility  
Colorado County, Texas  
Terracon Project No. 96187C01**

## GW Monitoring Program

August, 20 August, 20

Install 4 additional monitoring wells, sample 6 of 15 wells twice per year, and  
Scope: write one consolidated annual report. Starting in 6th year, reduce to one  
sampling event per year.

		Labor - Title	UNITS	COST	Year 1		Years 2-5		Years 6-30		
					Monitoring Well Installation (4)		Semiannual Sampling - Present costs per year		Semiannual Sampling - Present costs per year		
					Qty	Cost	Qty	Cost	Qty	Cost	
1.0	LABOR	1.1 Principal	hr.	142.00	1.00	142.00	1	142.00	1	142.00	
		1.2 Project Manager	hr.	125.00	8.00	1,000.00	8	1,000.00	6	750.00	
		1.6 Project Geologist/Scientist	hr.	108.00	48.00	5,184.00	48	5,184.00	30	3,240.00	
		1.7 Sr. Staff Engineer	hr.	95.00	0.00	0.00	0	0.00	0	0.00	
		1.8 Sr. Staff Geologist/Scientist	hr.	90.00	48.00	4,320.00	48	4,320.00	30	2,700.00	
		<b>Subtotal - Labor</b>				<b>10,646.00</b>		<b>10,646.00</b>		<b>6,832.00</b>	
		2.1 Employee #1	UNITS	COST	<b>TASK 1</b>		<b>TASK 2</b>		<b>TASK 2</b>		
		2.11 Meals	day	46.00	5.00	230.00	5	230.00	3	138.00	
2.0	TRAVEL	2.12 Lodging	day	91.00	4.00	364.00	4	364.00	2	182.00	
		2.16 Mileage	ea.	0.580	2000	1,160.00	0	0.00	0	0.00	
		<b>Subtotal - Empl. Name</b>				<b>1,754.00</b>		<b>1,594.00</b>		<b>1,320.00</b>	
		2.2 Employee #2	UNITS	COST	<b>TASK 1</b>		<b>TASK 2</b>		<b>TASK 2</b>		
		2.11 Meals	day	46.00	5.00	230.00	5	230.00	3	138.00	
		2.12 Lodging	day	83.00	4.00	332.00	4	332.00	2	166.00	
		2.16 Mileage	ea.	0.580	0	0.00	0	0.00	0	0.00	
		<b>Subtotal - Empl. Name</b>				<b>562.00</b>		<b>562.00</b>		<b>304.00</b>	
3.0	SUBCONTRACTORS	<b>Cost</b>				<b>TASK 1</b>		<b>TASK 2</b>		<b>TASK 2</b>	
		3.1 Mob/Demob		680.00	1	680.00	0.00	0.00	0.00	0.00	
		3.2 DPT Rig / Day		1,950.00	0	0.00	0.00	0.00	0.00	0.00	
		3.2 MW Borings/foot		46.00	140	6,440.00	0.00	0.00	0.00	0.00	
		3.3 Monitoring Wells/ea		775.00	4	3,100.00		0.00		0.00	
		3.3 Pad Completion, 4x4 stickup, Well Development		600.00	4	2,400.00		0.00		0.00	
		3.4 Decon		250.00	1	250.00		0.00		0.00	
		3.4 Drums/ea		48.00	0	0.00	0.00	0.00	0.00	0.00	
		3.5 Drill Crew Per Diem / Person / Day		350.00	3	1,050.00		0.00		0.00	
		3.51 Number personnel		0						0.00	
4.0	SUBCONTRACTORS	3.52 Number of days		0						0.00	
		3.6								0.00	
		3.7								0.00	
		3.8								0.00	
		3.9								0.00	
		3.10								0.00	
		3.11								0.00	
		<b>Subtotal - Drilling Services</b>				<b>13,920.00</b>		<b>0.00</b>		<b>0.00</b>	
4.0	SUBCONTRACTORS	<b>Cost</b>				<b>TASK 1</b>		<b>TASK 2</b>		<b>TASK 2</b>	
		4.0 LABORATORY TESTING									
		TPH (TX 1005)		60.00		0.00	12	720.00	6	360.00	
		TPH (TX 1006)		225.00		0.00		0.00		0.00	
		BTEX (8260), Incl. 5035 for soils,		50.00		0.00	14	700.00	7	350.00	
		RCRA 8 Metals		110.00		0.00	12	1,320.00	6	660.00	
		Chlorides, EC, Anions, pH SAR, ES		115.00		0.00	12	1,380.00	6	690.00	
		Select Metals		120.00		0.00		0.00		0.00	
5.0	Other Direct Costs (ODCs)	NORM (Pace Lab, Allen, TX)		150.00		0.00		0.00		0.00	
		TOX		160.00		0.00		0.00		0.00	
		<b>Subtotal - Laboratory</b>				<b>0.00</b>		<b>4,120.00</b>		<b>2,060.00</b>	
		<b>Cost</b>				<b>TASK 1</b>		<b>TASK 2</b>		<b>TASK 2</b>	
		5.1 RENTAL EQUIPMENT									
		Trimble GPS/Day		120.00		0.00		0.00		0.00	
		<b>Subtotal - ODCs</b>				<b>2,050.00</b>		<b>450.00</b>		<b>225.00</b>	

	TASK 1	TASK 2	TASK 2
1.0 Labor - Costs	10,646.00	10,646.00	6,832.00
2.0 Travel - Costs	2,316.00	1,156.00	624.00
3.0 Drilling - Costs	13,920.00	0.00	0.00
3.0 Drilling - Fees	1,392.00	0.00	0.00
4.0 Lab - Costs	0.00	4,120.00	2,060.00
4.0 Lab - Fees	0.00	412.00	206.00
5.0 ODCs - Costs	2,050.00	450.00	225.00
5.0 ODCs - Fees	205.00	45.00	22.50
SUBTOTAL - By Tasks	30,529.00	16,829.00	9,969.50

**Tank and Equipment Relocation, Utility Disconnects**  
**(Does not include Disposal of Fluids or Other Contents)**

August 2019

Dedicated Full Time Equipment	Hourly Rates			Alternatives 2, 3	Alternatives 4, 5, 6		
	140	80	\$	11,200	240	\$	33,600
Trackhoe w hammer w operator	105	80	\$	8,400	240	\$	25,200
Dump Truck w/ operator	140	80	\$	11,200	240	\$	33,600
Dozer w operator to grade	105	40	\$	4,200	120	\$	12,600
Vacuum Truck	45	40	\$	1,800	120	\$	5,400
Front-end loader with operator	80	24	\$	1,920	72	\$	5,760
Electrician	80	40	\$	3,200	120	\$	9,600
Welder	45	160	\$	7,200	480	\$	21,600
Roustabout costs	500	1	\$	500	3	\$	1,500
			\$	49,620		\$	148,860

Note: For Alternatives 4, 5, and 6 the level of effort has been multiplied by 3 because the large size and complexity of those alternatives.

**Alternative 2, 3, 4,5,6 - Bringing Hotspot Waste to Surface and Move to Staging Areas**

	Alternatives 2,3 <sup>1</sup>	Alternatives 4,5 <sup>2</sup>	Alternatives 6 <sup>3</sup>	Units
Soil to Move	100000	407000	200000	CY
Soil to Move w/ .25 Expansion	125000	508750	250000	CY
Costs of Excavator w/ Operator	140	140	140	Cost/hr
Time to fill 18 CY Truck	2	2	2	Trucks/Hour
Soil Moved per hour	36	36	36	CY/hr
Time to Move 100,000 CY	3472	14132	6944	Hours
Dedicated 18 CY Truck to Move Waste to Staging Areas w/ Operator	100	100	100	Cost/hr
Helper and Spotter	40	40	40	Cost/hr
Cost of Excavator	\$ 486,111	\$ 1,978,472	\$ 972,222	
Cost of Dump Truck	\$ 347,222	\$ 1,413,194	\$ 694,444	
Cost of Helper/Spotter	\$ 138,889	\$ 565,278	\$ 277,778	
Oversight, Clearance Sampling	\$ 100,000	\$ 200,000	\$ 200,000	
Total Costs	\$ 1,072,222	\$ 4,156,944	\$ 2,144,444	

Notes:

1. Alternatives 2 and 3 envision excavating only 100,000 CY of hotspot waste.
2. Alternatives 4 and 5 envision excavating all identified waste.
3. Alternative 6 envisions only excavating below grade waste which is not beneath the footprint of the landfill and cap. Estimated at 200,000 CY.

Alternative 2, 3, 4, 5, 6 - Excavation Fill

	Alternatives 2,3	Alternatives 4,5,6	Units
Volume of soil removed	100,000	200,000	Yd <sup>3</sup>
Soil need with compaction of 0.9	111,111	222,222	Yd <sup>3</sup>
Dozer is used to spread and compact soil			
Dozer spread rate	250	250	Yd <sup>3</sup> / hr
Time to spread and compact	444	889	hrs
Dozer cost \$	\$ 105	\$ 105	\$/hr
<b>Dozer cost \$</b>	<b>\$ 46,667</b>	<b>\$ 93,333</b>	<b>\$</b>
Soil cost / Yd3 \$	\$ 12	\$ 12	\$/Yd3
<b>Soil cost \$</b>	<b>\$ 1,333,333</b>	<b>\$ 2,666,667</b>	<b>\$</b>
<b>Cost to replace soil in Excavations \$</b>	<b>\$ 1,380,000</b>	<b>\$ 2,760,000</b>	<b>\$</b>

Note: Alternatives 4, 5, and 6 assume only a maximum of 200,000 CY of excavations would be filled.

Alternative 2, 3, 4,5 - Move, Stage Above Grade Waste

	Alternatives 2,3 <sup>1</sup>	Alternative 4 <sup>2</sup>	Alternative 5 <sup>3</sup>	Alternative 6 <sup>4</sup>	Units
Soil to Move	-	285,000	150,000	285,000	CY
Soil to Move w/ .25 Expansion	-	356,250	187,500	356,250	CY
Costs of Front End Loader w/ Operator	140	140	140	140	Cost/hr
Time to fill 18 CY Truck	3	3	3	3	Trucks/Hour
Soil Moved per hour	54	54	54	54	CY/hr
Time to Move Soil CY	-	6,597	3,472	6,597	Hours
Dedicated 18 CY Truck to Move Waste to					
Staging Areas w/ Operator	100	100	100	100	Cost/hr
Helper and Spotter	40	40	40	40	Cost/hr
Cost of Excavator	- \$	923,611	\$ 486,111	\$ 923,611	
Cost of Dump Truck	- \$	659,722	\$ 347,222	\$ 659,722	
Cost of Helper/Spotter	- \$	263,889	\$ 138,889	\$ 263,889	
Oversight, Clearance Sampling		\$ 100,000	\$ 100,000	\$ 100,000	
Total Costs	- \$	1,947,222	\$ 1,072,222	\$ 1,947,222	

Notes:

1. Staging is not required for Alternatives 2, and 3. The above grade waste is already in accessible piles. Alternative 2 envisions a landfill over the current above grade pile location (AOC-1 and surrounding). Alternative 3 envisions direct loading into dump trucks for off-site disposal.
2. See *Table 3, Intermediate Calculations* for special handling of Alternative 4 costs.
3. Alternative 5 will require a reduced amount of staging since many of the piles will be able to be loaded directly into a dump truck for off-site disposal.
4. Alternative 6 will require a reduced amount of staging since many, but not all, of the piles are already in the footprint of the envisioned landfill.

**Alternative 2 - 17 Acre Above Grade Landfill with Engineered Cap Overlapping on  
AOCs 1, 2, 3, and 5**

Landfill to hold all waste from AOC 1 plus an additional 100,000 cubic yards of hotspot material.

<b>Volumes of Waste to Consider</b>	<b>YD3</b>			
In Place Volume	305,000			
Volume Expanded 25%	381,250			
<b>Theoretical Square, Truncated Pyramid Shaped Landfill</b>				
	<b>Side 1 (FT)</b>	<b>Side 2 (YD)</b>	<b>Area (YD2)</b>	<b>Acres</b>
Landfill Base Footprint (B)	287	287	82,280	17
Landfill Top Footprint (T)	184	184	33,880	7
Landfill Height Above Grade, Slope Vertical Run) (V)		7		
Slope, (H) Horizontal Run-(Side 1 Top-Side 1 Bottom/2)		51		
Slope % (V/H*100)		14%		
Slope (H:V)		7		
<b>Theoretical Volume of Landfill</b>				
<b>Volume of Truncated Pyramid = H/3(T+B+(T*B))<sup>1/2</sup></b>				
<b>Theoretical Surface Area of Landfill (Sides plus Top)</b>				
	<b>Acres</b>	<b>YD2</b>	<b>FT2</b>	
Landfill Base Footprint	17	82,280	740,520	
Landfill Surface Area, faces only		48,847	439,623	
Landfill Surface Area plus Top		82,727	744,543	
<b>Assumptions:</b>				
Soil to groundwater pathway is likely complete but groundwater plume will be monitored for plume stability.				
<b>1. Bring in additional hotspot waste, level the waste to allow placement of a geomembrane cap.</b>				
	<b>Unit Costs</b>	<b>Units</b>	<b>Total Costs</b>	
Trackhoe w operator	140	80	\$11,200	
Dump Truck w/ operator	105	80	\$8,400	
Dozer w operator to grade	135	24	\$3,240	
			\$22,840	
<b>2. Place 1 ft cement stabilized soil layer over waste.</b>				
Area Ft <sup>2</sup> * 1 Ft	744,543 Ft <sup>3</sup>			
Price of cement stabilized soil \$25/yd <sup>3</sup>	\$689,391.23			\$689,391
<b>3. Install layer of 40 mil Geomembrane for cap. (Use 50% excess.)</b>				
Geomembrane, 40mil	1,116,814 Ft <sup>2</sup>			
Cost of membrane installed, \$ 1.00	\$1,116,813.79			\$1,116,814
<b>4. Install 2 ft of clean soil over Geomembrane cap.</b>				
Area of Geomembrane * 2 Ft.	1,489,085 Ft <sup>3</sup>			
Price of clean soil, \$12/yd <sup>3</sup>	\$661,815.58			\$661,816
<b>4. Provide grass cover.</b>				
Cost of seed \$ 0.1. Ft <sup>2</sup>	\$111,681.38			\$111,681
<b>Total Cost of Landfill with Cap</b>	<b>\$2,602,541.97</b>			\$2,602,542



## Volume of a truncated square pyramid Calculator

[Home](#) / [Mathematics](#) / [Volume and surface area](#)

Calculates the volume, lateral and surface areas of a truncated square pyramid given the base and top sides, and height.

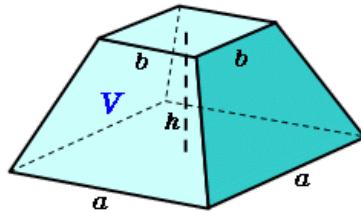
[Bookmarks](#)

Not registered.

[+ Bookmark](#)

### History

Volume of a truncated square pyramid



base side a

287

top side b

184

height h

7

[Execute](#) [Clear](#) [Store/Read](#) [Print](#) [14digit ▾](#)

volume V

394,410.33333333

lateral area F

48,959.085009832

surface area S

165,184.08500983

### Truncated square pyramid

$$(1) \text{ volume : } V = \frac{1}{3}(a^2 + ab + b^2)h$$

$$(2) \text{ lateral area : } F = 2(a+b)\sqrt{(\frac{a-b}{2})^2 + h^2}$$

$$(3) \text{ surface area : } S = F + a^2 + b^2$$

### Related Calculator

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[Volume of a rectangular cuboid](#)
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### Volume of a truncated square pyramid

[1-10] /101

Disp-Num [10 ▾](#)[◀ Back](#)[Next ▶](#)

[1] 2019/07/02 22:44 Male / 50 years old level / An engineer / Very /

**Purpose of use** calculate volume of concrete needed to fill form

[2] 2019/06/25 01:17 Male / 30 years old level / An engineer / Very /

**Purpose of use** Calculation of volume of a steel ingot produced by a radioactive metal melt treatment plant in Sweden.

[3] 2019/06/17 17:54 Female / 20 years old level / An engineer / Very /

**Purpose of use** design calculation

[4] 2019/05/22 17:11 Male / Under 20 years old / High-school/ University/ Grad student / A little /

**Purpose of use** Assignment

**Alternative 6 - 50 Acre Above Grade Landfill with Engineered Cap  
Overlapping on AOCs 1, 2, 3, 4, 5, 6 7, 8, and 9**

Landfill to hold all Identified Waste

<b>Volumes of Waste to Consider</b>		<b>YD3</b>
In Place Volume		691,000
Volume Expanded 25%		863,750
<b>Theoretical Square, Truncated Pyramid Shaped Landfill</b>		
	<b>Side 1 (FT)</b>	<b>Side 2 (YD)</b>
Landfill Base Footprint (B)	487	487
Landfill Top Footprint (T)	197	197
Landfill Height Above Grade, Slope Vertical Run) (V)		7
Slope, (H) Horizontal Run-(Side 1 Top-Side 1 Bottom/2)		145
Slope % (V/H*100)		5%
Slope (H:V)		21
<b>Theoretical Volume of Landfill</b>		<b>YD3</b>
Volume of Truncated Pyramid = $H/3(T+B+(T^2B)^{1/2})$		867,317
<b>Theoretical Surface Area of Landfill (Sides plus Top)</b>		<b>Acres</b>
		<b>YD2</b>
Landfill Base Footprint	49	237,160
Landfill Surface Area, faces only		198,671
Landfill Surface Area plus Top		237,391
		<b>FT2</b>
		2,134,440
		1,788,037
		2,136,517
<b>Assumptions:</b>		
Soil to groundwater pathway is likely complete but groundwater plume will be monitored for		
<b>1. Bring in additional hotspot waste, level the waste to allow placement of a</b>		
	<b>Unit Costs</b>	<b>Units</b>
Trackhoe w operator	140	320
Dump Truck w/ operator	105	320
Dozer w operator to grade	135	96
		\$91,360
<b>2. Place 1 ft cement stabilized soil layer over waste.</b>		
Area Ft <sup>2</sup> * 1 Ft		2,136,517 Ft <sup>3</sup>
Price of cement stabilized soil \$25/yd <sup>3</sup>	\$1,978,256.32	\$1,978,256
<b>3. Install layer of 40 mil Geomembrane for cap. (Use 50% excess.)</b>		
Geomembrane, 40mil		3,204,775 Ft <sup>2</sup>
Cost of membrane installed, \$ 1.00	\$3,204,775.24	\$3,204,775
<b>4. Install 2 ft of clean soil over Geomembrane cap.</b>		
Area of Geomembrane * 2 Ft.		4,273,034 Ft <sup>3</sup>
Price of clean soil, \$12/yd <sup>3</sup>	\$1,899,126.07	\$1,899,126
<b>4. Provide grass cover.</b>		
Cost of seed \$ 0.1. Ft <sup>2</sup>	\$320,477.52	\$320,478
<b>Total Cost of Landfill wih Cap</b>	<b>\$7,493,995.15</b>	\$7,493,995



## Volume of a truncated square pyramid Calculator

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Calculates the volume, lateral and surface areas of a truncated square pyramid given the base and top sides, and height.

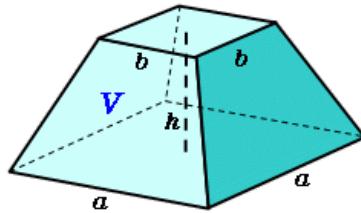
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### History

Volume of a truncated square pyramid



base side a

487

top side b

194

height h

7

[Execute](#) [Clear](#) [Store/Read](#) [Print](#) [14digit ▾](#)

volume V

861,660.33333333

lateral area F

199,760.64488532

surface area S

474,565.64488532

### Truncated square pyramid

$$(1) \text{ volume : } V = \frac{1}{3}(a^2 + ab + b^2)h$$

$$(2) \text{ lateral area : } F = 2(a+b)\sqrt{(\frac{a-b}{2})^2 + h^2}$$

$$(3) \text{ surface area : } S = F + a^2 + b^2$$

### Related Calculator

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[Edge length of a cube](#)
[Volume of a rectangular cuboid](#)  
[Volume of a tetrahedron](#)
[Volume of a regular tetrahedron](#)  
[Edge length of a regular tetrahedron](#)
[Volume of a equilateral triangular prism](#)  
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### Volume of a truncated square pyramid

[1-10] /101

 Disp-Num [10 ▾](#)
[◀ Back](#)
[Next ▶](#)

[1] 2019/07/02 22:44 Male / 50 years old level / An engineer / Very /

**Purpose of use** calculate volume of concrete needed to fill form

[2] 2019/06/25 01:17 Male / 30 years old level / An engineer / Very /

**Purpose of use** Calculation of volume of a steel ingot produced by a radioactive metal melt treatment plant in Sweden.

[3] 2019/06/17 17:54 Female / 20 years old level / An engineer / Very /

**Purpose of use** design calculation

[4] 2019/05/22 17:11 Male / Under 20 years old / High-school/ University/ Grad student / A little /

**Purpose of use** Assignment

### Alternatives 3, 5 Remove, Transport, Dispose

	Alternative 3	Alternative 5	Units
Above Grade Volume	204,994	284,328	CY
Below Grade Volume	100,000	406,636	CY
Total Volume in place	304,994	690,964	CY
Loose soil volume	381,243	863,705	CY
Truck loads of soil (based on 18 CY per truck)	21,180	47,984	Number of Trucks
Bucket size of excavator	3	3	CY
Efficiency of bucket 0.85	2	2	CY
Cycle time for bucket per minute	3	3	cycles/minute
Time to fill 18 Yd <sup>3</sup> truck, minutes	9	9	minutes
Time to fill 18 Yd <sup>3</sup> truck using excavator or loader, minutes (adjusted to be conservative)	24	24	minutes
Trucks	3	3	Trucks/hour
Round trip time to go to disposal facility (hours) (50 mph average)	3	3	hours
Round trip time to go to disposal facility (50 mph average)	180	180	minutes
Unloading time	20	20	minutes
Truck cycle time	224	224	minutes
Number of trucks to maximize use of excavator or loader = 1 + (truck cycle / bucket cycle)	10	10	
Soil moved per hour	45	45	CY/hours
Total time to move soil	8,472	19,193	hours
			\$
Truck cost w Operator at \$100/hour	\$847,206	\$1,919,344	
Excavator/loader cost w operator \$140/hr	\$1,186,088	\$2,687,082	\$
Costs of helper/spotter (\$40/hour)	\$338,882	\$767,738	\$
Oversight, Clearance Sampling	\$100,000	\$100,000	\$
Disposal cost @ \$40/ yd <sup>3</sup>	\$15,249,700	\$34,548,200	\$
<b>Total cost to haul and dispose soil</b>	<b>\$17,721,876</b>	<b>\$40,022,364</b>	\$

Total costs/cubic yard                                  46.5                                  46.3                                  \$/CY

**Alternative 4, Mix/Till Entire Site 4x/Year, Conduct Follow-up  
Composite Sampling**

		Unites
Size of Landtreatment Cell	110	Acres
Bulldozer with Ripping Shanks	\$ 140.00	\$/hr
Rate of Cross Ripping/2 passes	3	Acres/hr
Time to Rip Entire Landtreatment Cell	37	hr
Costs to Rip 1 x Year	\$ 5,133	\$
Costs to Rip 4 x Year	\$ 20,533	\$/year
Analytical - assumes 1 composite sample/4 acres (, TPH and EC	\$ 11,000	\$/year
Environmental Sampling and Partial Field Oversight (60 days/year; \$110/hr)	\$ 53,000	\$/year
Costs to Rip 4 x Year	\$ 84,533	\$