WASTE COAL PILES IDENTIFICATION AND USE OF COAL ASH REPORT HB657/SB120

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COMMONWEALTH OF VIRGINIA

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December 1, 2022

Dear members of the Virginia General Assembly,

As directed by House Bill 657/Senate Bill 120, the Virginia Department of Energy (Virginia Energy) is submitting the following report on waste coal and coal ash piles. In consultation with the Virginia Department of Environmental Quality (DEQ), Virginia Energy retained the services of Karmis, LLC and Marshall Miller & Associates, Inc. to assist in providing the requested details of these waste coal and coal ash sites in the Commonwealth.

Waste coal sites fall under the category of abandoned mine land features. Virginia's Abandoned Mine Land (AML) Program was established in the late 1970's to address public health, safety and the environment issues related to coal mining that took place prior to the passage of the Surface Mining Control and Reclamation Act of 1977. The AML program is housed within Virginia Energy. Abandoned mine land related problems include landslides, stream sedimentation, hazardous structures, dangerous highwalls, subsidence, loss of water, acid mine drainage and open mine portals in addition to removal and remediation of waste coal storage sites. AML sites eligible for reclamation must have been mined prior to December 15, 1981. Virginia Energy is the sole entity authorized to manage reclaiming the site.

Throughout history, coal processing included the discard and stockpiling of coal remnants bound with rock. These waste materials were not deemed suitable or economical for steel or electricity markets and are commonly referred to as "garbage of bituminous" or gob coal. Prior to current regulations and separation techniques, gob piles became prevalent in Southwest Virginia and now present a pollution risk to Virginia's air and waterways.

Virginia Energy's Mined Land Repurposing (MLR) program applies for an annual grant from the U.S. Office of Surface Mining and Reclamation Enforcement (OSMRE) to reclaim high priority AML sites across the state. Grant funds are used to design reclamation plans, obtain consents for rights of entry, publish public notices in local newspapers to advertise for construction contractors and to ensure sites are reclaimed and problems abated according to the engineering design. Grant funds come from fees paid by the industry on each ton of coal mined. Historically, these fees were insufficient to fully reclaim all existing AML features in the Commonwealth. Reclamation fund terms require Virginia Energy to address the highest priority sites and, in most cases, waste coal piles did not meet that classification.

However, recently passed federal legislation has created a new funding source that will allow Virginia Energy to remediate nearly all coal waste sites over time. This report summarizes past research and data and discusses informative and innovative paths forward for the maximum remediation and utilization of waste coal. This report, along with the new funding, will establish the foundation by which Virginia Energy can start the removal and reclamation process.

In addition to waste coal concerns, the burning of coal to produce electricity has left a legacy of stored coal ash sites across the Commonwealth. These sites present a long-term liability to all of Virginia's electric ratepayers but could generate economic activity if the material could be safely removed and used productively. Additionally, once the material is removed, these and waste coal sites could be repurposed for economic activity.

Virginia Energy thanks the stakeholders who reviewed and contributed to this report. Virginia Energy considers this report to be the start of a process, not the completion of one, as we prepare for the substantial increase in funding for AML. Virginia Energy looks forward to a continued constructive relationship with stakeholders as work begins to address these important issues.

A Review of Options and Opportunities for Cleaning and Utilizing Waste Coal Piles in the Southwest Virginia Coalfields and Stored Coal Ash Sites in the Commonwealth of Virginia, in support of State Legislation under House Bill 657/Senate Bill 120

by

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Michael Karmis, Ph.D., P.E., LLC.

Blacksburg, Virginia

Submitted to:

Virginia Department of Energy

December 1, 2022

Foreword

This report, Karmis LLC (2022) Coal Waste Streams Report, was developed by Dr. Michael Karmis, Managing Partner, Michael Karmis, Ph.D., P.E., LLC. (Karmis LLC) and Stonie Barker Professor Emeritus of Mining Engineering and Director Emeritus of the Virginia Center for Coal and Energy Research (VCCER), Virginia Tech. The reported work was performed under a contract from the Virginia Department of Energy (Virginia Energy/VE). A detailed biography of Dr. Karmis is included in Appendix 1. The report should be cited as: "*Karmis LLC (2022), Report on Coal Waste Streams, Submitted to The Virginia Department of Energy, December 1, 2022.*"

The purpose of this report, and also that of additional companion reports from other studies performed simultaneously for, or by, Virginia Energy, was to assist the agency in compiling a comprehensive final written report, as required by state legislation, under House Bill 657/Senate Bill 120.

Dr. Karmis, in the course of completing this assignment, met multiple times with the members of the Virginia Energy team engaged in this project and also held discussions with Marshall Miller and Associates (MM&A), who authored a companion report for the agency, on location, type and size of the main waste coal piles of Southwest Virginia. Dr. Karmis also participated in the Stakeholders Working Group, organized by Virginia Energy, as mandated under House Bill 657/Senate Bill 120. Comments received on exploring opportunities and recommendations that could assist and promote the utilization and site development of coal mine waste, and especially coal ash waste storage facilities, were incorporated in the report as appropriate. Finally, in preparation of this report, Dr. Karmis also held discussions with a number of coal companies, coal waste owners and companies currently separating coal waste streams, as well as with state and federal regulators, involved in issues that are included in the Karmis LLC (2022) Coal Waste Streams Report topics. In addition, he engaged in discussions with the coal ash processing and marketing community and power companies that operate, or have operated, coal ash storage facilities.

Significant input for this report was contributed by Virginia Energy, the Virginia Department of Environmental Quality (DEQ) and a number of subject experts, mentioned in the acknowledgements below; the Author also reviewed published national and international literature of interest to the discussion presented in this report; and, consulted standards for acceptable and proven Best Engineering and Management Practices (BEPs, BMPs) produced by major organizations that are active in the space of mine/coal waste or coal ash waste storage and recycling, pertinent to his assignment.

Finally, the opinions expressed in this report are solely those of the Author, are rendered to the degree of expected engineering and scientific certainty and best available engineering practices and may be subject to further study and review if additional data on this assignment become available.

Acknowledgements

The Author of this report would like to specifically acknowledge the numerous discussions with and contributions of the Virginia Energy team members working in this project, especially, Will Clear, Deputy Director; Lesa C. Baker, AML Program Director; Daniel Kestner, Innovative Reclamation Program Manager; Jesse L. Whitt, Mapping Specialist; Michael A. Skiffington, Director of Policy and Planning; and Megan Sturgill, Procurement Officer. Thanks are also due to the Virginia DEQ coal ash team, led by Kathryn Perszyk, Director, Land Protection and Revitalization Division, for valuable information and discussion and for providing an inventory of CCR (Coal Combustion Residuals) sites in the Commonwealth.

Mr. Danny Gray, President & CEO of *Gray Energy Technologies*, made significant contributions to the report, particularly in the discussion within the coal ash section. His more than 40 years of knowledge and experience in the electric utility energy services and the coal ash management industries were invaluable to that section of the report.

Margaret Radcliffe provided invaluable editorial and document organization support and critical review of the presented material.

Thanks are also due to the following colleagues and experts for providing important material and contributing critical discussion and review of the report material, to ensure accuracy and completeness:

- Gus Jansen, Geologist, Virginia Energy (retired)
- Marshall Miller & Associates Team that completed the companion report "Virginia Gob Piles Analysis, Quantification and Volumetrics"
- Dr. Wencai Zhang, Assistant Professor, Virginia Tech
- Dr. Zach Agioutantis, Professor, University of Kentucky
- Dr. W. Lee Daniels, Professor Emeritus, Virginia Tech
- Will Payne, Managing Partner, Coalfield Strategies
- Bill Almes, Civil & Environmental Consultants, Inc.

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AIME	American Institute of Mining, Metallurgical and Petroleum Engineers
AASHTO	American Association of State Highway and Transportation Officials
ACAA	American Coal Ash Association
AMD	Acid Mine Drainage
AML	Abandoned Mine Land
AMLER	Abandoned Mine Land Economic Revitalization
ARC	Appalachian Regional Commission
ASTM	American Society for Testing and Materials
BEPs	Best Engineering Practices
BMPs	Best Management Practices
BTU	British Thermal Units
CAPP	Central Appalachia(n)
CBP	Carbon-Based Products
CM	Critical Minerals
CCB	Coal Combustion Byproducts
CCR	Coal Combustion Residuals
CDCLTU	Coal Direct Chemical Looping hydrogen production
CM	Critical Minerals
CO	Carbon Ore
CRIRSCO	Committee for Mineral Reserves International Reporting Standards
CTU	Coal-to-Urea
C-U	Consolidated - Undrained
DAC	Disadvantaged Community
DEQ	Virginia Department of Environmental Quality
DOE	US Department of Energy
VDOT	Virginia Department of Transportation
EPA	US Environmental Protection Agency
ESA	Environmental Site Assessment
FEED	Front End Engineering Design
HSWA	Hazardous and Solid Waste Amendments
ICMM	International Council on Mines and Metals
IMCC	Interstate Mining Compact Commission
Karmis LLC	Michael Karmis, Ph.D., P.E., LLC.
LOI	Loss of Ignition
MM&A	Marshall Miller & Associates
NAAMLP	National Association of Abandoned Mine Land Programs
NETL	National Energy Technology Laboratory
NGO	Non-Governmental Organization
OSM	US Office of Surface Mining
RCRA	Resource Conservation and Recovery Act
REE	Rare Earth Elements
SCM	Supplementary Cementitious Material
SEC	US Securities and Exchange Commission
SMCRA	Surface Mining Control and Reclamation Act
SME	Society for Mining, Metallurgy and Exploration
SSEB	Southern States Energy Board
TDS	Total Dissolved Solids
TR	Technical Route

TRL	Technology Readiness Level
TVA	Tennessee Valley Authority
US	United States
USGS	US Geological Survey
VAM	Ventilation Air Methane
VCCER	Virginia Center for Coal and Energy Research
VCHEC	Virginia City Hybrid Energy Center
VDMLR	Virginia Division of Mined Land Repurposing
VE	Virginia Department of Energy
Virginia Energy	Virginia Department of Energy
WIIN	Water Infrastructure Improvements for the Nation Act of 2016

Report Summary

The Author, under the approved scope of work with the agency, provides in this report a basic background of waste coal storage features and practices in the Southwest Virginia coalfields and addresses potential cleaning, utilization and reclamation options. Common definitions are explained, waste characterization practices are discussed and opportunities for commercial utilization, using circular economy and responsible principles, are presented.

As directed by the legislation and the agency, special reference is made throughout the report to best practices, including operational, health, safety and environmental standards in accordance with US, as well as global guidelines, beyond state and federal regulatory and compliance requirements. This has been addressed by developing a Performance Protocol for life cycle analysis and utilization of waste storage facilities generated by coal mining and coal fired electric generation.

In addition, the report addresses experiences in similar gob pile efforts from the other Central Appalachian states, which are defined in this report as Southwest Virginia, Southern West Virginia, East Kentucky and East Tennessee, based on Appalachian Regional Commission (ARC) and US Geological Survey (USGS) criteria. Within the region, coal mining and coal waste practices are similar, and, in preparation of this report, the Author and the Virginia Energy leadership convened a Central Appalachian States Gob Piles discussion group, for initiating and continuing discussions amongst the state agencies and other stakeholders on gob piles related topics, and to share technologies, practices and experience into the future.

In addition to waste coal, and as directed by House Bill 657/Senate Bill 120, the report also discusses opportunities and challenges to recover construction products, and other useful product streams, from stored coal ash sites in the Commonwealth of Virginia and to identify opportunities for such current and future sites to support construction of public infrastructure projects in the Commonwealth.

The discussion and comments of the Central Appalachian States Gob Piles Committee were invaluable and are reflected in this report. In addition, the Author participated in the meetings of the broad Stakeholders Working Group, organized by Virginia Energy, and those discussions and recommendations were incorporated in the development of the report.

Finally, the Karmis LLC (2022) Coal Waste Streams Report in support of House Bill 657/Senate Bill 120 presents a roadmap to the future, by identifying technologies and best practices that can promote the responsible renewal of gob piles and coal ash waste storage facilities. Incentives for gob piles and coal ash owners have also been addressed, as well as administrative challenges that must be considered and overcome to encourage a healthy and viable industry on cleaning and utilizing waste coal piles in the Southwest Virginia Coalfields and stored coal ash sites in the Commonwealth of Virginia.

The report also recognizes the work and wealth of knowledge already developed by key state agencies, mainly Virginia Energy on gob piles and DEQ on coal ash storage, and proposes that Virginia considers committing additional resources, both in funding and personnel, to improve the capability and expertise of these agencies in the renewal of gob piles and coal ash facilities. Such a capacity upgrade will also justify increased expectations for Virginia Energy to actively engage and participate in private-public partnerships that are usually needed to respond to the competitive federal solicitations available in the recently announced major infrastructure bills.

Objectives and Scope of Work

The Virginia General Assembly, during the 2022 Legislative Session, passed House Bill 657/Senate Bill 120 that essentially ask the Virginia Department of Energy to lead an effort in the state to accomplish a number of tasks, summarized below:

Bill Language - On Scope

From § 1.

- *…identify the approximate volume and number of waste coal piles present in the coalfield region of the Commonwealth and options for cleaning up such waste coal piles, including the use of waste coal in generation of electricity*
- *…collaborate with other states in which waste coal piles are located that are members of the Appalachian Regional Commission to identify best practices for cleaning up waste coal piles*.
- *The Department shall report its findings and any recommendations by December 1, 2022*.
- *For purposes of this act, "waste coal" means usable material that is a by-product of previous coal processing operations.*

From § 2.

- *…convene a working group, including, as appropriate, representatives from the Department of Environmental Quality, the Virginia Department of Transportation's Transportation Research Council, and other stakeholders, to evaluate the opportunities for the development of public infrastructure projects at current or proposed sites for the storage of coal ash in the Commonwealth.*
- *The working group shall report its findings and any recommendations by December 1, 2022.*

Budget Language

The Virginia Department of Energy, in the first year from the general fund, is authorized to undertake work for:

- *…geotechnical and related consulting support that may be required to identify the approximate volume and number of waste coal piles present in the coalfield region of the Commonwealth*
- *…the evaluation of opportunities to use coal combustion residuals for construction purposes in public infrastructure projects in the Commonwealth.*

The Karmis LLC (2022) Coal Waste Streams Report addresses the objectives described above. In addition, the report includes some supplementary information and discussion that, although not required to meet the stated objectives, are important to consider for completeness and a better appreciation of the information presented.

For the purpose of this report, the focus was placed on coal gob piles, ash landfills and inactive impoundments, rather than active coal impoundments and ash ponds. Since the first priority for gob piles is the ones classified as Abandoned Mine Land (AML, defined in the next section), this is reasonable and appropriate at this stage.

In addition, in the case of Coal Combustion Residuals (CCRs), because the regulations eliminated unlined active impoundments, most of the Virginia-based CCR sites are either inactive ponds or (primarily) landfills. Virginia law, discussed later in this report, that requires Dominion Energy and American Electric Power to remove the CCRs from old inactive impoundments and mandates preference for beneficial use of the material, is more directed at former impoundments that are inactive "dry deposits," except for the lower levels in the old impoundments which may have saturation levels.

It is also important to provide some familiarity in this report on three aspects that are imperative in dealing with waste streams created either during the coal extraction (gob piles) or generated after combustion in a coal-fired plant (coal ash), namely: **Definition of Terms, Material Ownership and Regulatory Responsibility**. The first is addressed by including a comprehensive Glossary of Terms that is presented in Appendix 2, which provides well accepted definitions of common terminology and explanations of terms used in this report. The Glossary also facilitates searching for additional information on the large bibliography related to this topic. The other two items are discussed separately in the following sections.

Environmental Renewal

In the literature, as well as in practice, a number of terms have been used to describe the treatment of the gob piles and other waste streams such as Coal Combustion Residuals (CCRs) or coal ash, and the host sites, known collectively as the 5Rs, i.e., **Reclamation, Rehabilitation Remediation, Restoration and Renewal. Such terms as Re-mining, Re-use, or Re-processing,** have also been used, mainly by operators engaged in utilization of these stored waste products. In this report, the Author proposes that **Renewal** is the most appropriate for describing utilization of gob piles and CCRs, because this term also integrates actions implied by the other terms, i.e., reclaim/rehabilitate/remediate/restore, and thus Renewal is a more encompassing and realistic description.

Another concept to be defined and discussed is the **circular** versus the **linear economy**. Under the linear economy scheme, the system is organized to **take-make-dispose**. This is in contrast to the circular economy, which describes a more efficient and sustainable practice, eliminating or significantly reducing waste, Figure 1. In this case, waste material is treated as a new resource for recovering and producing value-added, down-stream products. Combining these concepts, **Renewal** can now be better defined as **a process in which a waste or damaged resource is renewed in a sustainable manner using circular economy principles.**

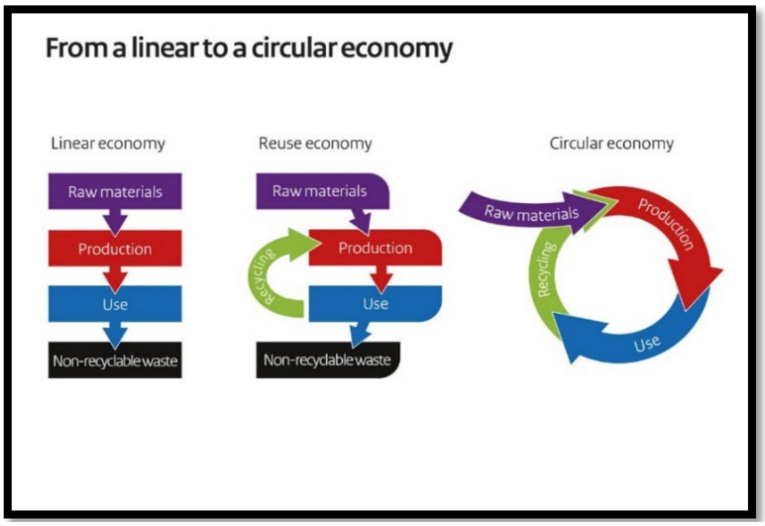
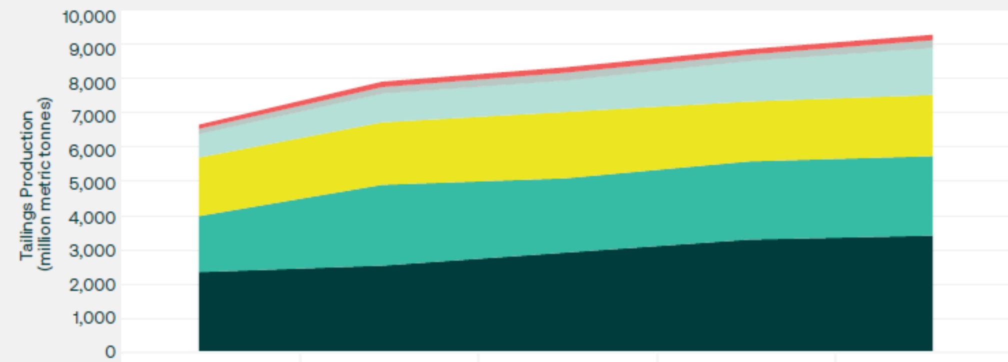


Figure 1: Circular Economy (Source: https://3dprint.com/245147/circular-economy-d/)

Performance Protocol

It is important at this point to introduce the work of the International Council on Mines and Metals (ICMM), a unique industry body of "global leadership of the mining and metals industry, committed to climate and environmental resilience, social performance, governance and transparency, and innovation for sustainability through responsible production of metals and minerals" (from https://www.icmm.com/). Mining-produced **Tailings**, the corresponding term for mine waste in the minerals/metal mining industry, is a subject of significant focus, and ICMM has been active in providing guidelines and best practices working with a number of major mining companies, global partners and NGOs, including the United Nations. These documents are available for download from the ICMM website. One interesting example from a recent ICMM Report is depicted in Figure 2, which provides an appreciation of waste material annual production for different commodities (ICMM, 2022, p.31).



	2010	2012	2014	2016	2018
Alumina	113	128	144	150	163
Nickel	157	220	243	207	228
Iron Ore	687	820	934	1164	1374
Coal	1717	1864	1937	1761	1813
Gold	1656	2355	2205	2302	2351
Copper	2371	2570	2926	3338	3440

Figure 2: Estimate of Global Annual Tailings by Commodity - Coal Waste is Included as Coal tailings (Quoted in ICMM, 2022)

One guideline that ICMM has followed for tailings that should, in the Author's view, also be considered in this report, as applied to gob piles and coal ash waste, is the difference between **Conformance** and **Performance.** In this context, Conformance deals with accountability and assurance in current operations, which can be verified by a third party validation, while Performance primarily addresses strategy, value creation and resource utilization (ICMM, 2021a). In the case of tailings, long term safety, stability and accountability are the prime considerations and thus the term conformity had been adopted and promoted by the ICMM. In dealing with utilization of gob piles and CCR-produced coal ash, however, for the purpose of the Karmis LLC (2022) Coal Waste Streams Report, the development of a **Performance Protocol** is the preferred terminology, adding value and resource utilization as well as providing safety and assurance to stakeholders that the organization is working effectively, efficiently and sustainably.

1 COAL GOB PILES

Part 1 of the Karmis LLC (2022) Coal Waste Streams Report focuses on Coal Gob Piles. For the purpose of this report, it is first important to clarify some key definitions and terminology. “Coal waste” disposal areas, are known by many terms, including "gob piles," "slate dumps," "waste piles," and "refuse" The same material is also referred to in the international literature as “colliery waste” (see Glossary in Appendix 2). In addition, this report addresses **Post-SMCRA** and **Pre-SMCRA or AML** gob piles and sites, as defined in section 1.1.1 below. To add to this perplexity of terms, a gob pile is often reserved by agencies and power plants to include **only Pre-SMCRA or AML** sites (see Glossary Appendix 2, Coal Waste Terminology) and waste coal as **Post-SMCRA.** Consistent with the language of the legislation, and for the purpose of this report, both **Post-SMCRA** and **Pre-SMCRA or AML** sites are encompassed by the terms “coal waste” or “gob pile.”

1.1 Introduction

A number of complex issues must be taken into account when considering beneficial use of gob piles. These include the regulatory environment, evaluating the composition of the gob piles, the local geology, and potential environmental impacts.

1.1.1 Regulatory Environment

The Surface Mining Control and Reclamation Act (SMCRA) of 1977 ensures that coal mining operations are subject to federal and state regulation to prevent impacts to communities and the environment. Mines are governed under Title V of this Act, which includes rules and regulations that must be followed, including requirements for reclamation and restoration of mines once mining has ceased. Mine operations under Title V, therefore, are also identified as “Post-SMCRA,” “Post-Law” or “Post-Act.”

Historic coal mining, conducted prior to the enactment and enforcement of SMCRA, has impacted thousands of acres of land and water resources in the coalfields, with no legally responsible party in existence to clean up the now abandoned mines, also referred to as “Pre-SMCRA” or “Pre-Law” sites. These facilities are, however, governed under Title IV of SMCRA, which established the Abandoned Mine Land (AML) reclamation fee, paid by the modern mining industry, on the basis of current coal production in cents/ton produced and deposited into the AML Trust Fund. AML funds are then distributed to the states, using a current coal production-based formula, for investing in qualified AML projects. This reclamation fee is the primary source of revenue to address the lingering impacts of pre-SMRCA or AML unregulated coal mining sites and eliminate hazards such as landslides, mine openings, water impairment, et cetera.

The exact acreage of refuse in the Southwest Virginia coal fields is difficult to estimate, but modern and fully stabilized and reclaimed disposal facilities, generated since the passage of the

SMCRA Act in 1977, cover thousands of acres and abandoned refuse piles dot the landscape in almost every major mined watershed.

Depending on age and permit performance criteria, gob piles are candidates for environmental renewal under AML conditions, while others have been released from active monitoring requirements. Zipper and Skousen (2021 a, b) provide a good overview of the existing historic and current regulatory environment for the region, including details on water quality emission standards and issues.

The gob pile interest in most cases will fall back to the landowner. All previous leases and agreements, if honored, would void the AML eligibility and the reclamation responsibility would fall back to those who hold the lease or conducted the operations. Furthermore, if a leaseholder claims the rights to the operation, or the remaining resources, they will have to permit the site to recover the gob coal. If the site is developed as an AML project, any funds from the sale of incidental coal or gob recovered, would come back into the AML program and would not go back to the owner, **unless** it was developed under the "Enhancement Rule."

The Enhancement Rule involves Abandoned Mine Land Enhancement (AML) for projects resulting from a 1999 rule change of the federal Office of Surface Mining (OSM) to increase the amount of reclamation accomplished. The rule change now allows government financing on projects to be less than 50% of the total budget, and the coal removal is exempt from permitting requirements. Proceeds from the sale of coal go to offset the cost of project reclamation. The enhancement rule requires Title IV (AML) and Title V (active) branches to make findings and determinations that a number of required standards have been met.

Sources for additional information are available from the US Office of Surface Mining, Reclamation and Enforcement, from the Virginia Department of Energy, from the Interstate Mining Compact Commission (IMCC), and from the National Association of Abandoned Mine Land Programs (NAAMLP).

1.1.2 Gob Pile Material Description

Stabilization and environmental renewal of coal waste disposal piles is a costly and challenging problem and one that has been extensively discussed in the relevant literature for many years, particularly with reference to the Southwest Virginia coalfields, (Daniels & Stewart, 2000; Joost et al., 1987; Nickerson, 1984; Stewart & Daniels, 1992). A number of references have also addressed coal waste processing, and combined engineering, environmental and compliance challenges (Chugh & Behum, 2014).

A significant portion of the raw coal mined predominantly underground today in Southwest Virginia and Central Appalachia is produced by high-efficiency, automated mining systems and large-scale equipment (e.g., high-extraction room and pillar mining or longwall mining methods). These systems often require significant clearance and space or, simply, a mining height greater than the actual thickness of the particular coal seam mined. As a result, during the mining process, portions of the roof and/or floor, above and below the coal seam, are mined, in addition to any natural partings and other rock impurities that are within the coal seam. The corresponding gob piles have different composition and size distribution, therefore, from the older ones, i.e., AML gob piles.

The general range of bulk coal refuse properties in Southwest Virginia is given in Appendix 4, Table 3 based on work by Stewart (1990) and continued observations by Daniels et al. (2018) through the mid-2000s. These data reflect the bulk surface (0 to 25 cm) chemical and physical properties of a wide range of older abandoned (Pre-SMCRA) piles and active facilities.

1.1.3 Preparation Plant Influences

Modern coal cleaning technologies have allowed coal preparation facilities to become quite efficient at removing waste compounds, and even low-grade coals, from run-of-mine coal, to derive the saleable product. These refuse materials vary from coarse fragments removed by physical screening to very fine materials removed by chemical processes such as flotation and density separation. It also still contains high carbon (or BTU) material that can be returned to a coal-fired power plant. In addition, this produced waste contains traces of critical minerals that, given certain concentration and available processing technologies, can be a new, valuable, resource for recovering such important minerals commercially.

1.1.4 Gob Pile Environmental Impacts

Refuse disposal areas/gob piles are generally constructed as large valley fills, with surface waters diverted around or through drains under the completed fill and are commonly hundreds of acres in size. The refuse is compacted in place, and the entire facility must meet rigorous geotechnical stability standards. Many refuse disposal areas are constructed using a "zoned disposal" concept where refuse slurry generated in the fine coal cleaning circuit is impounded behind a compacted dam of coarse refuse. The face and sideslopes of the structure are generally constructed to a steep gradient to minimize the total disturbed area and are specifically designed to ensure stabilization and structural integrity. The majority of the environmental concerns associated with reuse and processing of existing the gob pile refuse materials are due to oxidation of pyritic-S, which is intentionally removed from the marketed coal and concentrated into refuse. Pyritic-S can vary from <0.1 to > 1.5% in Southwest Virginia coal refuse (Stewart & Daniels, 1992) and when exposed to near-surface conditions oxidizes to sulfuric acid, generating very low (< 3.8) soil:water pH values along with high levels of Total Dissolved Solids (TDS)(> 500 mg/L) and soluble Al, Fe, and Mn. Release of Se or other trace elements (e.g. As, Cu, Ni and Zn) is also of concern in certain settings.

1.1.5 Geologic Considerations

The depositional environment of coal and its associated strata has a direct relationship to the properties of the coal seams, including coal bed thicknesses, sulfur and trace element content, and coal quality. Coal refuse is usually composed of rock fragments derived from inter-seam shale or siltstone partings and waste rock materials from above or below the seam. The refuse shares many properties with the associated coal seam. Southwest Virginia coal seams and associated strata are generally low in sulfur compared to other Appalachian states. As a result, Virginia coal refuse tends to be comparatively low in sulfur and associated potential acidity (see Appendix 4, Table 3). However, coal refuse is enriched in a range of heavy metals relative to average soil materials, the majority of which are associated with pyrite or other reduced sulfides.

1.1.6 Pyrite Oxidation, Potential Acidity and Acid Drainage

Most of the environmental risks associated with environmental renewal of coal refuse occur as a result of pyrite oxidation and the production of acidity (Daniels and Stewart, 2000; Joost et al., 1987; Nickerson, 1984). Highly acidified water dissolves the mineral matrix around it as it leaches downward, becoming charged with aluminum (Al), manganese (Mn), and other metals, cations and salts. The average fresh refuse material in Virginia requires 10 to 15 tons of $CaCO_3$ per 1000 tons of raw refuse to neutralize the acidity present, assuming complete reaction of pyrite and carbonates via the regular acid-base accounting technique (Appendix 4, Table 3). Pyrite oxidation, the production of sulfate salts, which may leach heavy metals such as copper, nickel, selenium and zinc, is often associated with pyrite and other sulfide minerals (Appendix 4, Table 4). These leachates, collectively referred to as Acid Mine Drainage (AMD), must be properly curtailed or treated, to prevent water quality threat.

1.1.7 Stabilization and Revegetation Challenges and Best Practice

Once an existing gob pile has been excavated, processed and beneficial materials removed, a certain mass of materials will remain on site that must be stabilized and revegetated. Assuming they are somewhat similar to the original coarse + fine refuse materials, direct revegetation and long-term re-stabilization can be challenging (Daniels & Stewart, 2000; Daniels et al., 1989; and Daniels & Zipper, 2018). Major limitations include low fertility (particularly for nitrogen and phosphorus), limited rooting depth and water holding capacity, and high surface temperatures, particularly on south facing slopes.

The development of a successful gob pile reuse area environmental renewal strategy must take a number of factors and processes into account. Each area of the coal refuse fill and final proposed configuration must be carefully assessed for properties and problems and the final reclamation approach must be tailored accordingly. Water quality of deep seepage and runoff should be expected to decline for some period of time during and following the excavation and reprocessing activities and all monitoring and discharge controls maintained.

Best results in surface reclamation and revegetation of gob piles have been achieved by incorporating lime and plant nutrients into a suitable soil cover above the refuse. Vegetation can be established directly on some refuse materials after amendment with lime and fertilizers and/or reduced topsoil thickness (Daniels & Stewart, 2000; Daniels et al., 2018).

In addition to appropriate testing for physical and chemical properties related to plant growth, potential acidity should be determined by a qualified laboratory using either the conventional US Environmental Protection Agency (EPA) acid-base accounting method or the hydrogen peroxide oxidation technique. These two techniques give somewhat different estimates of the liming requirement for refuse materials (see Appendix 4,Table 3), with the peroxide oxidation technique being more conservative.

1.1.8 Managing Short and Long-Term Water Quality Concerns

The long-term emission of acidic leachates from gob piles is a significant regional issue. These leachates present a much more difficult challenge than surface revegetation. To stop leachate production, water flow through the pile must be limited, but this is very difficult in the humid leaching environment of Southwest Virginia. There is evidence that a vigorous vegetative cover can reduce acid drainage by intercepting and transpiring rainfall, consuming oxygen in the rooting zone, and through several other mechanisms. Even moderately sulfidic refuse materials should be expected to discharge acidic leachates and long-term water treatment strategies should be anticipated and designed. For such piles, the leachates will have to be neutralized with caustic additions and/or acid treatment wetlands.

Acid-treatment wetlands are not currently accepted by regulatory authorities as a "walk-away" solution to acid leachate water quality problems. Where sufficient land area is available, however, wetland treatment systems have proven to be a more cost-effective means of treating acid water than alkaline chemical systems. Design requirements of acid treatment wetlands for the region are reviewed by Zipper & Skousen (2021a,b) and Zipper & Jage (2018), who provide specific details for application to Southwest Virginia.

The most effective technology for eliminating the acid leachate potential at gob pile sites is the bulk-blending of alkaline materials with the waste refuse, as it is placed in the fill. Ground agricultural limestone serves this purpose well, but would add a considerable cost to refuse disposal. Isolating acid-forming with impermeable leaching barriers is also a viable option but may not be practical at most existing refuse disposal sites due to lack of suitable fine textured materials and/or cost of synthetic liners. Thus, it will be of critical importance for all seepage/drainage and surface water runoff from any gob pile excavation and reprocessing operation to be contained in an appropriate detention structure, monitored and treated if necessary to meet current operational DEQ and/or the Virginia Division of Mined Land Repurposing (VDMLR) discharge standards.

1.2 Identification and Location of Gob Piles in Southwest Virginia

Work has already begun on the identification of gob piles and their locations in Southwest Virginia; however, further study and confirmation of the data collected will be necessary, including verifying the ownership, determining whether access is possible or practical, and planning each gob pile repurposing project.

1.2.1 Identification and Location

Virginia Energy, over the last few years, has been active in identifying, locating and verifying gob piles in the coal producing counties, with emphasis on those which are Pre-SMCRA or AML, as discussed in section 1.1.1. The agency focused resources and efforts originally in three counties, Dickenson, Wise and Lee. This significant work investigated 157 reported gob points and was able to identify 93 AML gob piles in these counties. Following the requirements included in House Bill 657/Senate Bill 120, Virginia Energy contracted Marshall Miller & Associates (MM&A) to complement the agency's work by expanding the existing database with gob pile information in three more coal producing counties: Buchanan, Russell and Tazewell. The MM&A work investigated 137 reported gob points and identified 60 gob piles. The results of this effort are summarized in Figure 3 based on the data collected by Virginia Energy and Figure 4 that includes the results of the work performed by MM&A (MM&A, 2022).

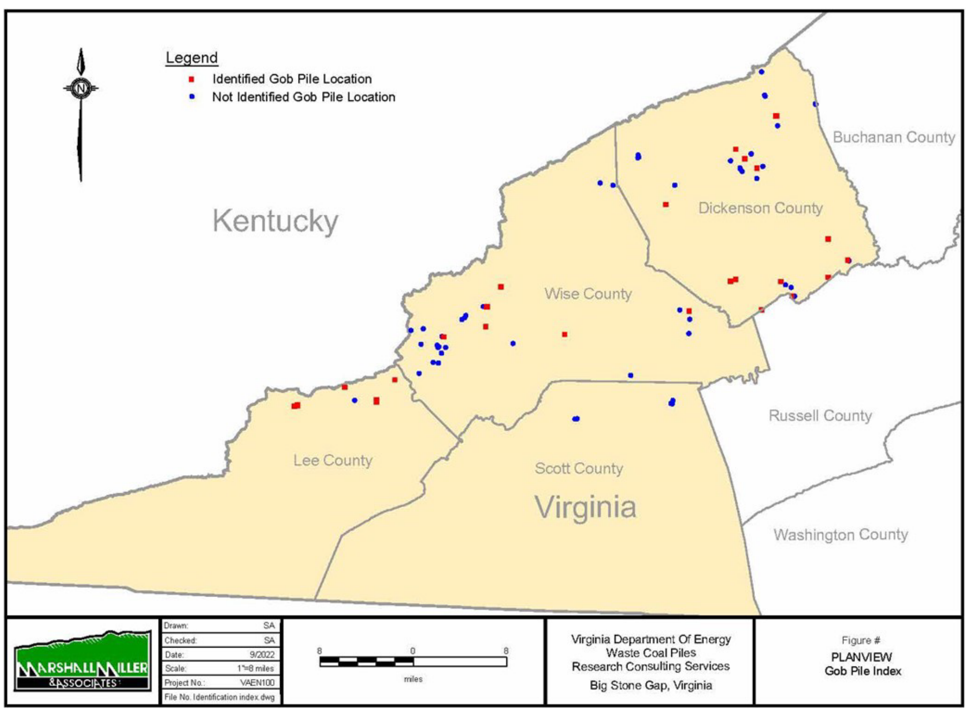


Figure 3: Virginia Energy Gob Pile Index

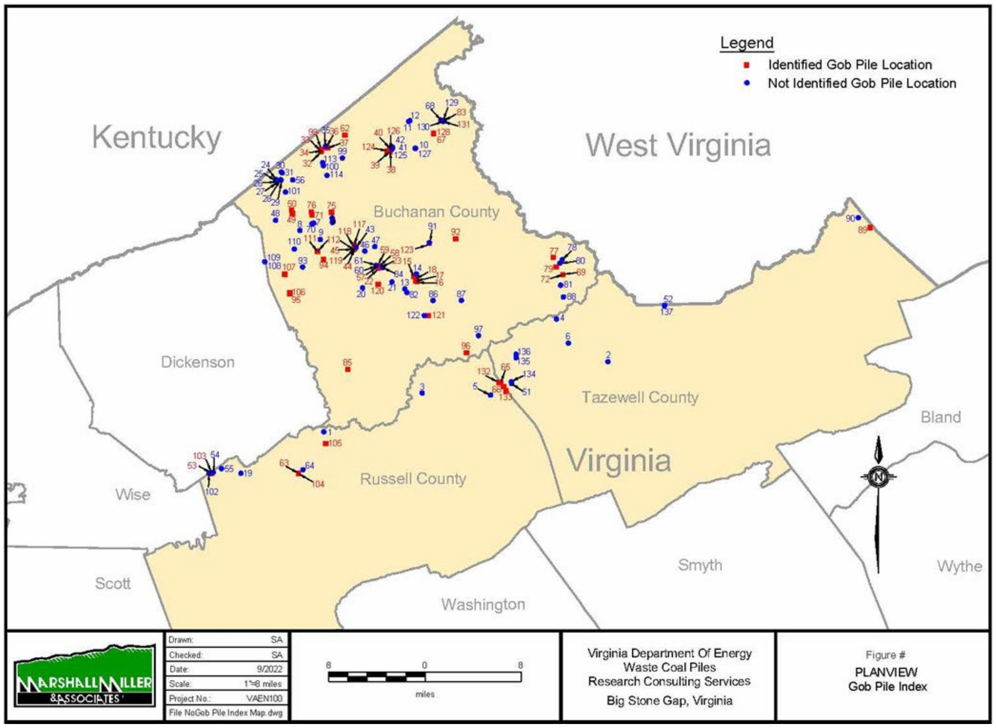


Figure 4: MM&A Gob Pile Index

In addition, the MM&A report, although limited in scope as a 'desktop study," used multiple data sources to collect, assemble and verify, using a comprehensive digital database, the location and approximate volume of the gob piles in the counties in question. Furthermore, the MM&A report was able to develop an error rating for each gob pile, by considering eight major sources of error and assessing the impact of these errors on the results. The MM&A report also recommended mitigation strategies that could lower or eliminate the relative errors, when refining and verifying data and results (MM&A, 2022).

The combined work of MM&A and Virginia Energy located and generated approximate volumes for 152 sites, as shown in Figure 5. The coal waste data will be available to the public in the form of an interactive dashboard and web map (Figure 6). This application will reflect real time changes in the coal waste data set as it is compiled and edited.

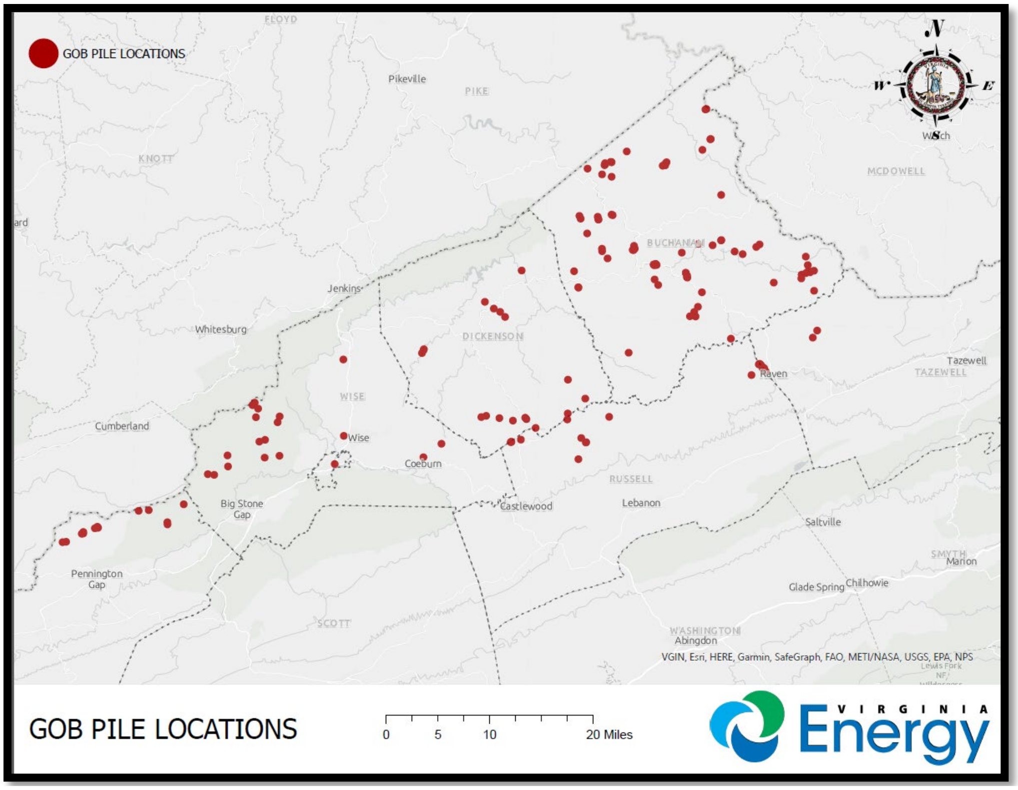


Figure 5: Virginia Energy & MM&A Gob Pile Locations

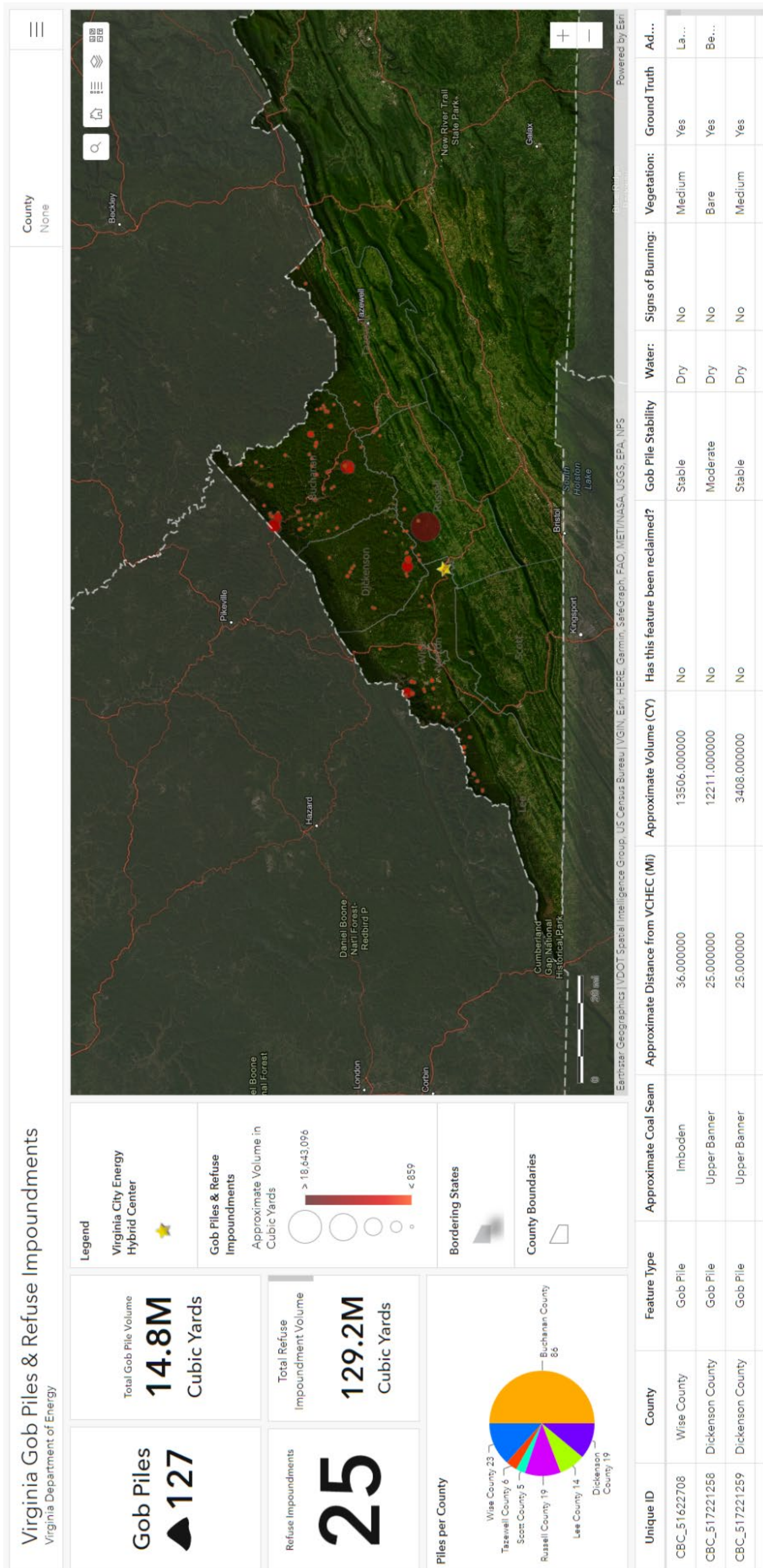


Figure 6: Virginia Gob Piles & Refuse Impoundments Dashboard

The MM&A study and the Virginia Energy database on AML gob piles, are a first step towards characterization and prioritization of gob piles for future environmental renewal and potential utilization for down-stream products. Further studies will be necessary to confirm and verify the collected data; design a comprehensive sampling program using Best Engineering Practices; identify gob pile composition and geotechnical characteristics; establish a systematic testing program to identify and classify potential valuable resources using acceptable standards for mineral resources reporting; and select appropriate technologies to remediate, sort, process and market carbon products, comprising material eligible for fuel in power generation, down-stream carbon-based products, and recovery of critical minerals, including rare earths.

The discussion above was focused on AML Pre-Law gob piles. In the course of the Karmis LLC (2022) Coal Waste Streams Report, however, all categories of gob piles are considered, and this will require identification and verification of active or inactive Post-Law, non-AML gob piles, that are required to be permitted by the state, under Title V regulations. Permit requirements are specified under Title V for removing more than 250 tons of coal, as well as notice requirements for exploration removing 250 tons of coal or less. In addition, re-disturbing released permits, for a non-AML gob pile that has been released, when a new applicant wishes to re-disturb the site and reprocess the coal, require that the new applicant must adhere to the previously mentioned requirements for acquiring a permit or notice. Figure 7 compiled by Virginia Energy, depicts Title V permits in SW Virginia.

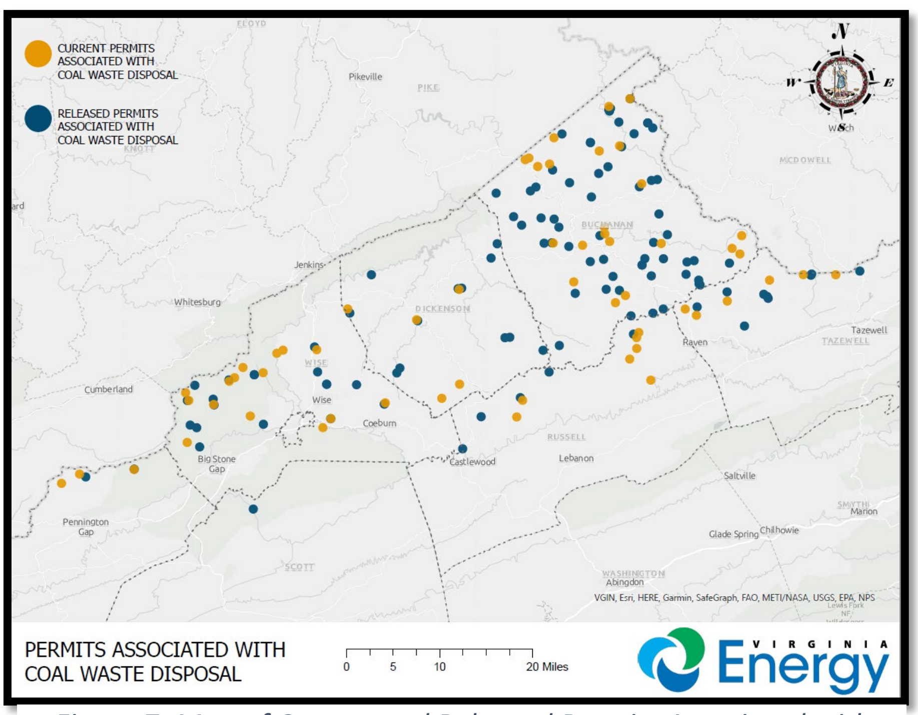


Figure 7: Map of Current and Released Permits Associated with Refuse Disposal (Source: Virginia Energy)

1.2.2 Ownership, Access and Planning

Ownership and site access play a significant role in accessing, verifying, sampling and testing gob piles for potential remediation and future utilization. Potential resource ownership, along with surface lands ownership and any leasing agreement for current or future resource recovery or surface facilities siting, are the first considerations for a gob pile renewal project. This implies that owners must be incentivized, and developers can justify a commercial project and secure off take agreements.

As mentioned in more detail later in the report, planning of a gob pile project follows specific steps that start with pile inspection, mapping, volumetric assessment, and preliminary sampling. A positive evaluation will then lead to more rigorous and expensive coring, testing and analysis to estimate options for the safe remediation and renewal of the particular gob pile. Safety and environmental considerations will be critical, as will the technologies that can be used to develop downstream products.

Finally, if the project is viable, all state and federal permits required to pursue renewal activities associated with the gob pile must be identified, completed and submitted for approval. A project schedule consistent with the evaluation and design processes must be developed to meet the requirements of regulating agencies as the project advances through specific milestones. That should be coupled with a risk management plan, a “live” document that involves risk, severity, probability and mitigation measures.

1.2.3 Gob Pile Screening Versus Characterization

The information collected for this study can allow for some “preliminary screening” of southwest Virginia gob piles, but not any kind of detailed characterization and prioritization for renewal actions. The latter requires extensive sampling, testing and analysis, and evaluation of downstream value chains and financial and commercial exposures of the gob pile project.

A preliminary gob pile screening option is, however, possible, by simply comparing the two properties of gob piles identified in the work of Marshall Miller and Associates (MM&A, 2022) and the Virginia Energy database, namely volume and error rating. This is presented in Figure 8 and Figure 9 where the more promising (green) and least promising (orange) gob piles for renewal are identified for the MM&A-investigated gob piles and for the combined gob pile data from MM&A and Virginia Energy.

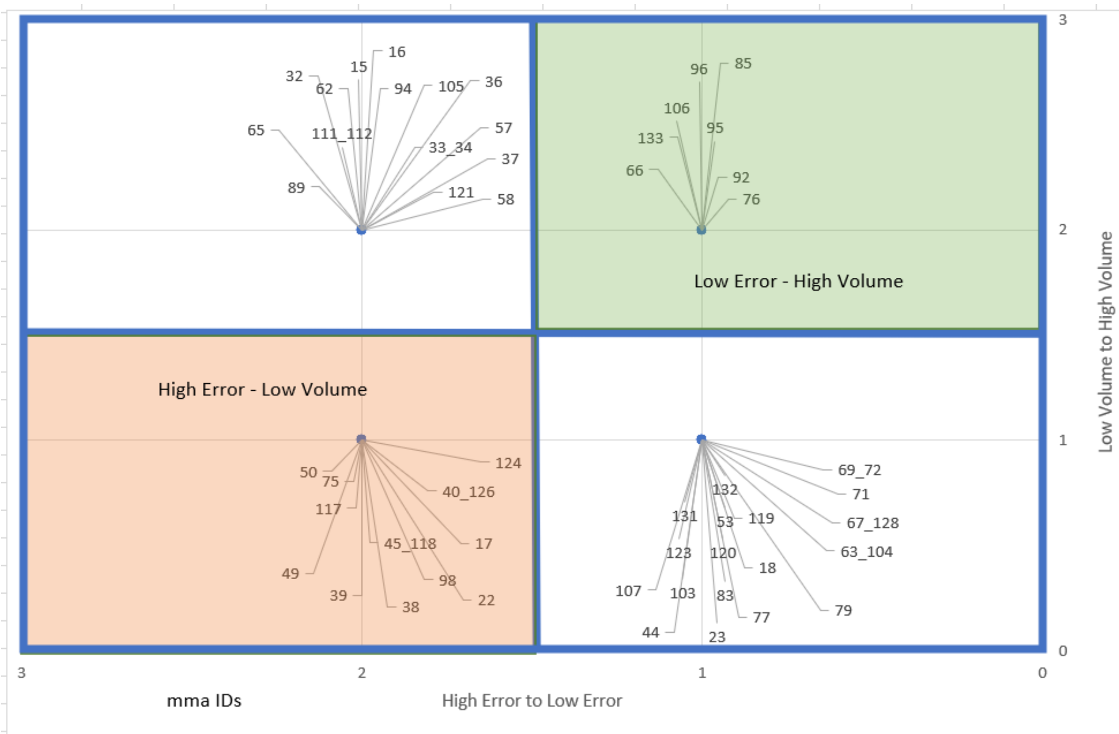


Figure 8: Screening based on the MM&A Gob Pile Data

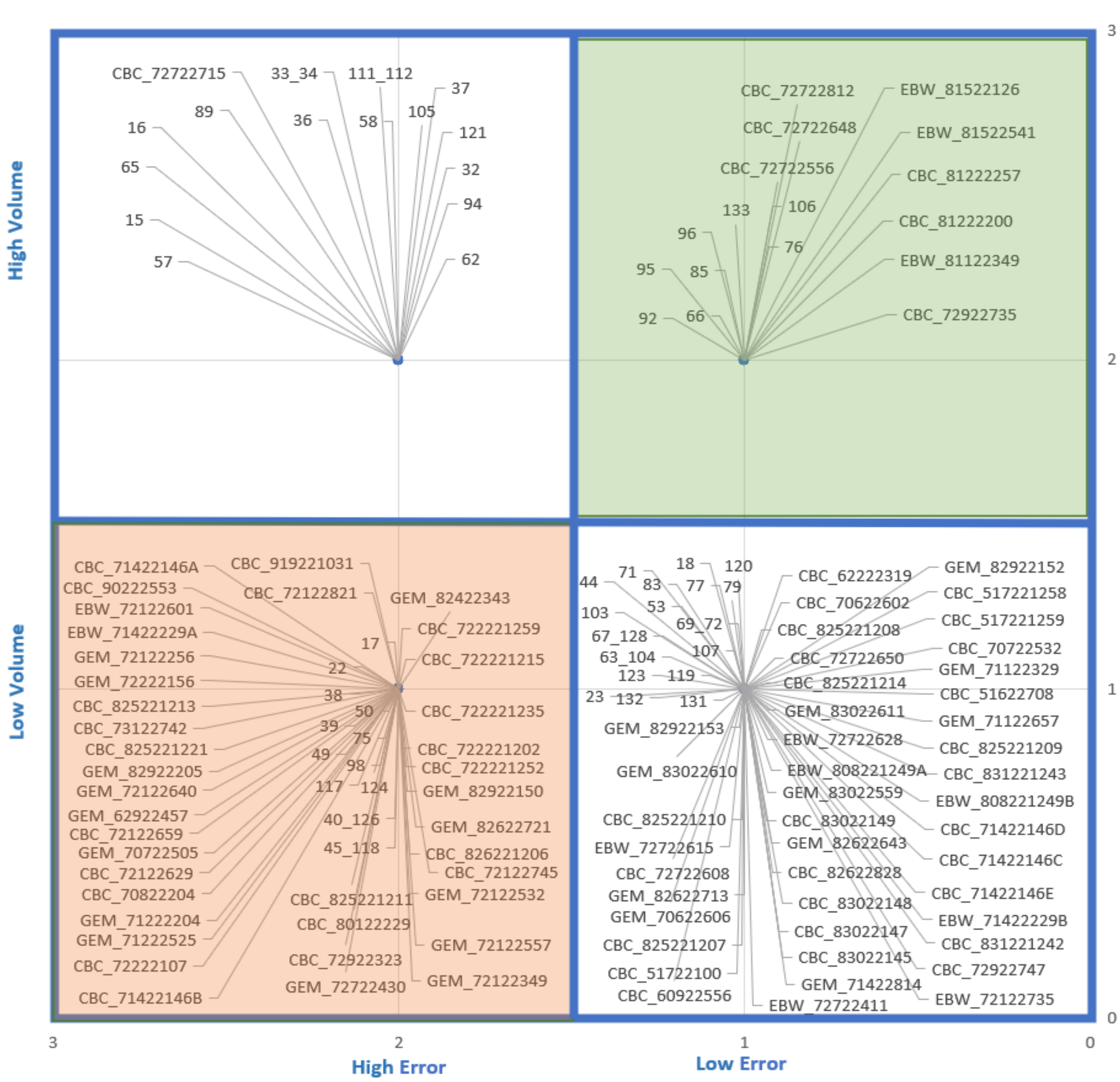


Figure 9: Screening for all Gob Pile data, MM&A and Virginia Energy

1.3 Gob Piles Renewal Process – Separation, Processing and Downstream Value Chains

Waste coal piles/gob piles still contain a certain amount of organic matter that can be recovered as a clean coal product. However, sufficient liberation through crushing and/or grinding is required since the majority of the organic matter is partially or completely encapsulated within the inorganic matter. While the organic matter in gob piles is a suitable feedstock for electricity generation and high-value carbon products productions, the inorganic matter can also be processed as a potential source for recovering critical minerals.

1.3.1 Clean Coal Production

Several different technical routes can be employed to produce clean coal from waste coal piles/gob piles (Figure 10). The most straightforward Technical Route (TR1) is to pulverize all the material to a size sufficient for liberation, followed by physical separation such as froth flotation to produce clean coal. Given the fact the both the organic matter and inorganic matter will be pulverized to the liberation size, the energy consumption for particle size reduction will be prohibitively high. In addition, the clean coal product will be produced as a fine powder that requires efficient dewatering and thermal drying to meet the moisture content and heating value specifications set by the end user. The thermal drying step will also consume a lot of energy.

As an alternative of TR1, TR2 uses staged-pulverization/separation to reduce energy consumption. Instead of pulverizing all the material to a size for sufficient liberation of all organic matter, the material is pulverized to a coarser particle size so that the organic matter is partially liberated and/or only a portion of the organic matter is sufficiently liberated. Then, the pulverized material is classified into different size fractions and each fraction is processed using an appropriate physical separation method. After separation, if the products of certain size fractions are not qualified, the products will be further pulverized and separated to reject more inorganic matter. Compared with TR1, the most significant advantage of TR2 is that only a portion of waste coal piles/gob piles is pulverized to the particle size for sufficient liberation of all the organic matter, thus saving a lot of energy. In addition, unlike TR1, a portion of the organic matter is produced as coarse clean coal in TR2; therefore, energy consumption for thermal drying is reduced.

In TR3, waste coal piles/gob piles are subjected to dry separation with or without preliminary crushing. In this step, a portion of the inorganic matter in waste coal piles/gob piles is rejected as coarse refuse, while the remaining material is further processed through staged pulverization/separation (TR2). By adding dry separation at the beginning of the process, the amount of material fed to the downstream wet separation can be reduced. Therefore, water consumption can be reduced through TR3.

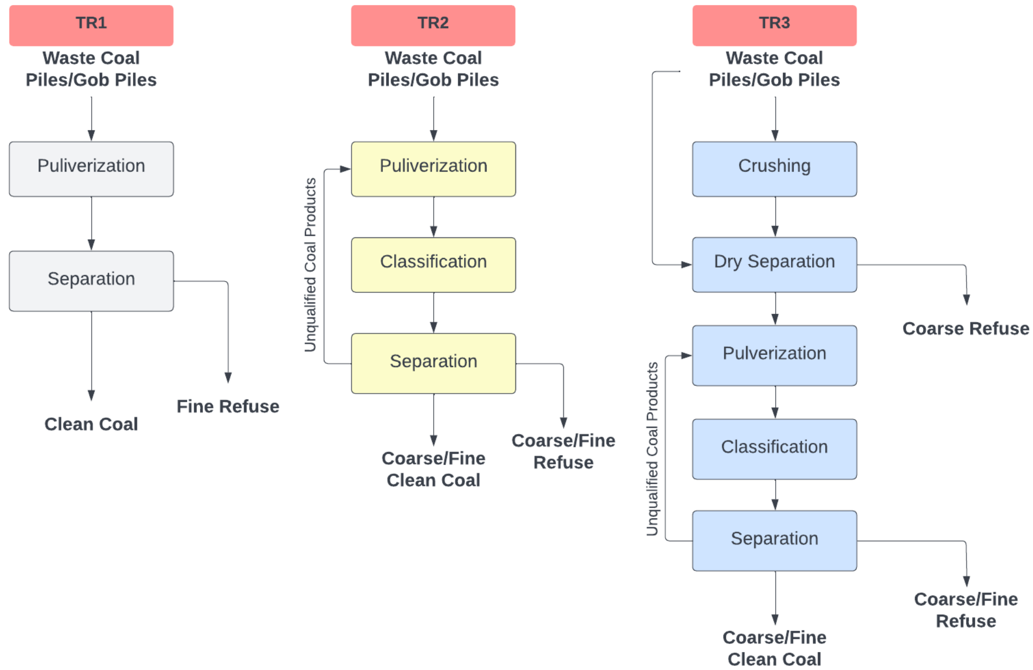


Figure 10: Technical routes for clean coal production from waste coal piles/gob piles

Effective size ranges of application of different particle separation technologies are shown in Figure 11 and Figure 12. Sensor-based sorting is a dry separation technology that enables the rejection of coarse refuse particles at an early stage of processing. Therefore, sensor-based sorting is a good candidate for the dry separation step in TR3. In terms of the wet separation step, a combination of different technologies that are suitable for different size ranges can be applied. For example, dense medium vessel, dense medium cyclones, spirals, and froth flotation can be used to process coarse, medium, fine, and ultrafine size fractions respectively.

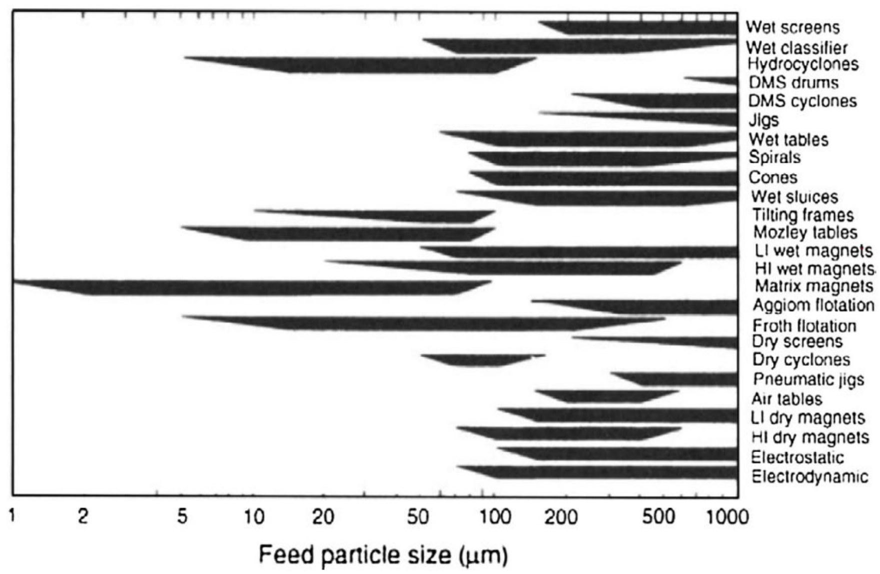


Figure 11: Effective range of application of different separation technologies (Mulenga et al., 2016)

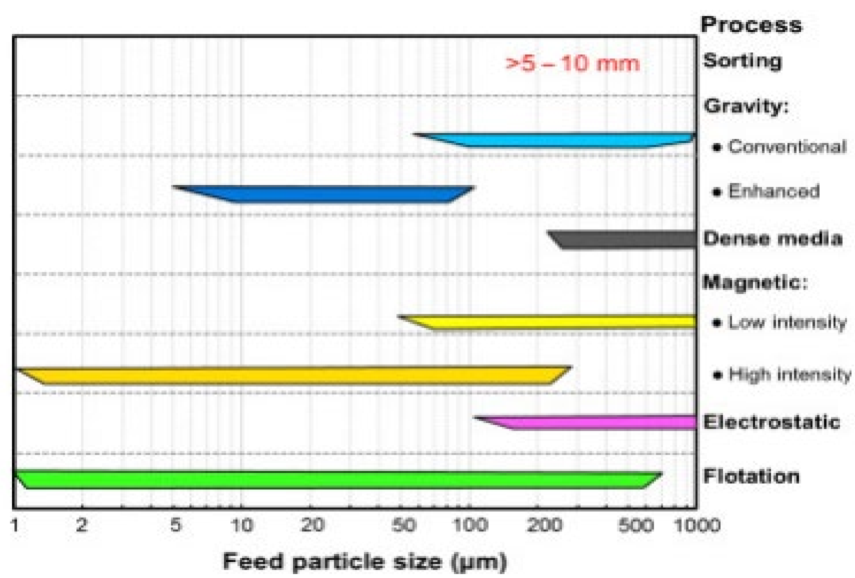


Figure 12: Effective range of application of different separation technologies (Wills & James, 2015)

1.3.2 High-Value Carbon Products Production

The clean coal products obtained from waste coal piles/gob piles can be beneficially used for different purposes. Generating high-value carbon products is a desirable option due to the high economic value of these products. Appendix 5 provides a detailed description of the different types of carbon products that can be produced from coal. Given a number of factors, such as feed material characteristics and production cost, it was concluded that the clean coal recovered from waste coal pile/gob piles is suitable for the production of graphite, activated carbon, and carbon foam. Although some other carbon products, such as graphene and graphene oxide, have been successfully prepared from coal in the laboratory, it is challenging to commercialize due to the high preparation cost and complex preparation process.

1.3.3 Critical Minerals Production

The occurrence modes of critical minerals can be generally classified into mineral association, intimate organic association, and organic association. Low-rank coals contain more humic substances than high-rank coals, therefore, a larger fraction of critical minerals exist in low-rank coals than high-rank coals. However, during coal purification processes to produce clean coal and high-value carbon products, most critical minerals existing as mineral associations are rejected into refuse streams along with other inorganic matter, and a portion of intimate organically associated critical minerals are released. In addition, when reported on a whole mass basis, the contents of most critical minerals in low-ash clean coal are lower than high-ash middling and refuse. Therefore, it can be concluded that the inorganic matter rejected from coal cleaning and upgrading processes is the major source of critical minerals.

This conclusion was confirmed by a field survey of 20 coal preparation plants in eastern USA (Luttrell et al., 2019). The survey showed that around 73% and 12% of REEs in run-of-mine coals are transferred to coarse refuse and fine refuse streams, respectively. Many studies have been carried out to recover critical minerals from coal-based materials. Appendix 6 details the advantages and disadvantages of different methods. An approach that integrates biomining and phytomining was recommended based on the comparison between the different methods. This approach will facilitate the recovery of critical minerals from waste coal piles/gob piles in a sustainable manner (green chemical, low energy consumption, minimal solid waste management). As shown in Figure 13 below, Virginia and the Central Appalachian region have been recognized as a major potential source for rare earths for more than 20 years. During this period, numerous US DOE as well as privately-funded projects have been conducted in the region and there is a significant depth of knowledge in the community of evaluating and processing these minerals, up to a small-plant scale, still under a low Technology Readiness Level (see Appendix 13).

A recent study from the Evolve-Central Appalachia research team has identified the most promising coal seam strata for recovering rare earth elements in the region (Table 1).

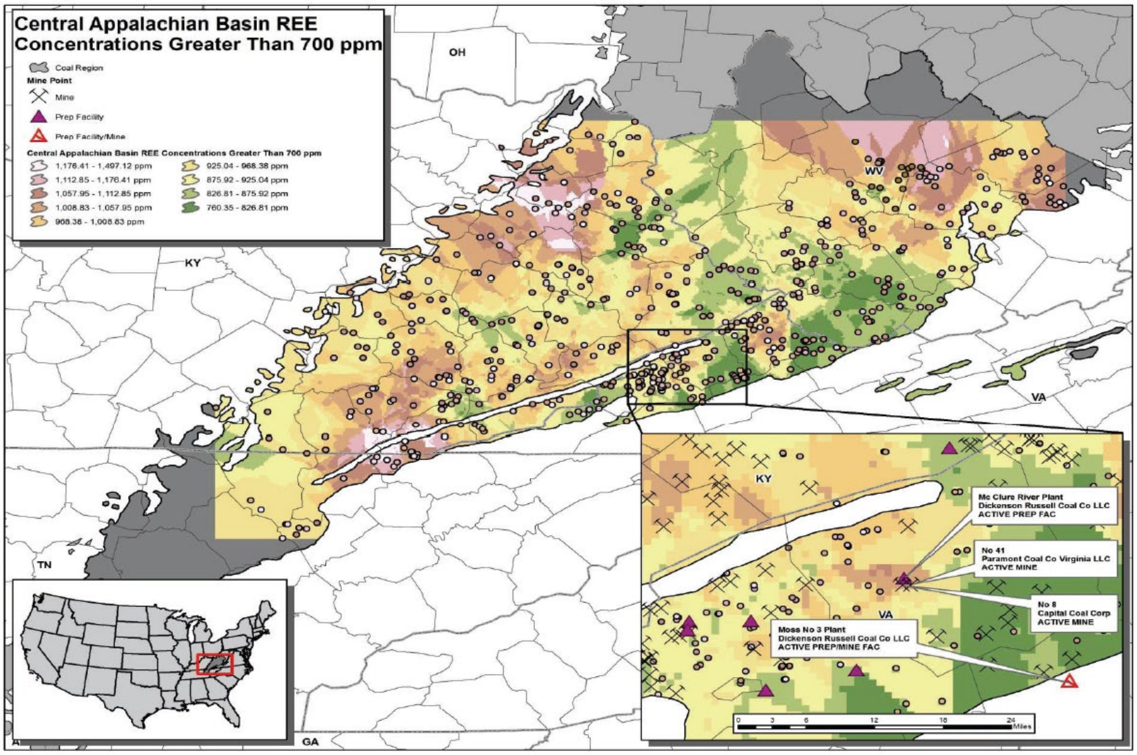


Figure 13: Rare Earths Concentrations in Virginia and Central Appalachia (Source: J.M. Ekmann, NETL Search and Discovery Article #80270 (2012), Posted November 26, 2012)

Table 1: Summary of Data for "Top Ten" Coal Seams in Each State in Basin with Regard to Number of Available REE-Containing Samples and Consideration of Minimum, Maximum, and Averages of REE Suite in Samples (Evolve Central Appalachia, 2022)

	KENTUCKY					TENNESSEE			
	COUNT	MAX	MIN	AVERAGE		COUNT	MAX	MIN	AVERAGE
BLUE GEM	41	193.01	25.05	68.88	REX	2	46.75	32.10	39.43
UPPER ELKHORN NO 2	33	191.05	44.92	72.44	BLUE GEM	2	44.10	44.04	44.07
JELLICO	42	170.06	44.07	91.84	MASON	3	61.66	34.78	45.64
UPPER ELKHORN NO 3	44	261.06	45.27	111.84	PEWEE	4	72.14	50.45	63.30
UNKNOWN-BITUMINOUS C	46	485.25	40.93	117.91	JELLICO	3	99.63	43.62	79.90
PEACH ORCHARD	62	323.30	45.54	133.58	COAL CREEK	2	117.34	52.65	84.99
HAZARD NO 7	30	212.49	40.99	135.81	POPLAR LICK	3	140.83	34.94	100.11
HAZARD	59	420.31	50.79	140.85	BIG MARY	4	230.84	78.89	135.63
BROAS	31	661.07	65.72	148.87	WINDROCK	2	232.17	55.74	143.95
HINDMAN	30	413.30	71.79	164.93	WALNUT MOUNTAIN	2	186.24	141.95	164.10
FIRE CLAY	89	732.51	45.44	189.56					

	VIRGINIA					WEST VIRGINIA			
	COUNT	MAX	MIN	AVERAGE		COUNT	MAX	MIN	AVERAGE
LYONS	35	210.98	30.39	81.41	REDSTONE	42	453.77	43.67	104.65
BLAIR	18	149.24	47.06	82.07	BECKLEY	43	344.60	30.12	111.41
DORCHESTER	71	273.42	30.70	91.12	SEWELL	51	484.58	37.37	122.94
CLINTWOOD	67	394.08	30.41	93.18	POCAHONTAS NO 3	48	396.95	47.17	136.72
NORTON	18	159.34	39.39	94.20	NO 2 GAS	37	840.13	60.41	154.99
KENNEDY	18	278.48	37.57	96.70	EAGLE	54	833.07	52.64	156.91
UPPER BANNER	31	320.15	56.04	124.21	CAMPBELL CREEK	30	766.85	46.51	196.15
SPLASHDAM	24	498.31	48.20	124.30	COALBURG	39	846.04	52.16	203.98
LOWER BANNER	19	413.96	34.49	131.04	NO 5 BLOCK	38	1,389.71	51.44	245.11
JAWBONE	17	321.39	43.17	165.73	STOCKTON	27	712.13	70.17	247.86

1.3.4 Fertilizer Production

The materials in waste coal piles/gob piles can also be used to produce fertilizers (Mikos-Szymańska et al., 2019; Saputra, 2017; Tsetsegmaa et al., 2018; Wang et al., 2021; Zhou et al., 2022). Coal contains a moderate amount of hydrogen that is mainly associated with the organic matter; thus, clean coal produced from waste coal piles/gob piles can be used to produce urea. Two approaches, coal-to-urea (CTU) process and coal direct chemical looping hydrogen production process (CDCLTU), which have been documented in the literature for producing urea from coal, are detailed in Appendix 7 (see Figure 29). Besides urea, other types of fertilizer have also been produced, such as brown coal humic acid fertilizers (Tsetsegmaa et al., 2018), brown coal/biochar based compound fertilizer (Mikos-Szymańska et al., 2019), and coal gangue-biochar composites (Wang et al., 2021). The first two types of fertilizer are constrained to brown coal that contains large amounts of humic acids. The last type of fertilizer is prepared by mixing coal refuse with biomass and then pyrolyzed at 700°C. In addition, only after adsorbing nutrients, such as phosphate, can the coal gangue-biochar composites be used as a fertilizer. Coal has also been directly used to prepare fertilizer by mixing with nutrients, salts, and bio-stimulants after appropriate crushing and grinding (see Figure 30 in Appendix 7). The major issue with this method is that the efficiency of the prepared fertilizer has not been verified at the benchtop.

Based on the above discussion, it can be inferred that CTU and CDCLTU are the most viable methods to produce fertilizer from coal since they do not have a strict requirement on coal rank and the fertilizer produced can be sold as a common commodity. CDCLTU outperforms CTU given the low operating costs and carbon emissions; however, both CTU and CDCLTU require the construction of a separate plant to process coals from different waste coal piles/gob piles. The opportunity for producing fertilizers from gob coal is still in an early stage of development, but worthy of pursuit, as it has significant downstream applications, particularly in light of the recent spike of fertilizer prices produced by traditional processes.

1.3.5 Recommended Flowsheet for Cleaning Waste Coal Piles/Gob Piles

Based on the discussions above, a processing flowsheet for cleaning waste coal piles/gob piles while producing valuable products has been designed. As Figure 14 shows, dry separation such as sensor-based sorting is first applied to remove coarse refuse and obtain a material with lower ash content than the feed. The material is then subjected to pulverization, size classification, and separation to generate refuse, fine coal, and coarse coal. Critical minerals are recovered from the refuse through bio-mining and phytomining. In the meantime, the adverse environmental impact of the refuse is remediated with the contribution from phytomining. Fine coal is primarily used to generate high-value carbon products through different methods, such as molten-salt electrolysis to produce graphite, and self-foaming to produce carbon foam. Coarse coal is combusted to generate electricity, while 8-50 mesh fraction of the coarse coal can be obtained by screening and used for activated carbon preparation. The flowsheet maximizes the beneficial use of waste coal piles/gob piles and, due to the application of dry separation, bio-mining, and phytomining, the water consumption and environmental impact of the overall flowsheet are low.

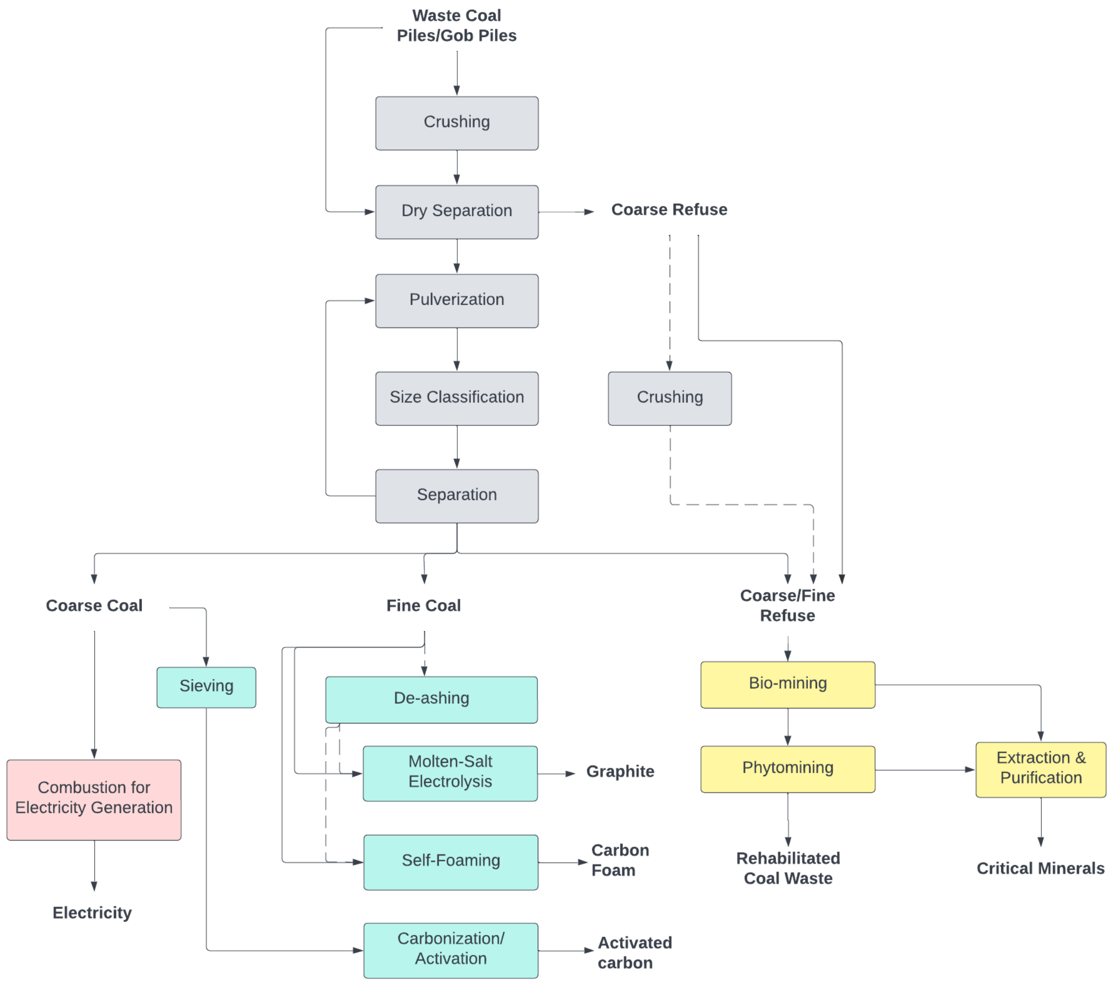


Figure 14: A recommended flowsheet for producing valuable products from waste coal pile/gob piles

1.4 Collaboration with Government Agencies, the Appalachian Regional Commission and the Central Appalachian States

House Bill 657/Senate Bill 120, as stated in Objectives and Scope of Work, request that the Virginia Energy report also include a discussion and plan to "…collaborate with other states in which waste coal piles are located that are members of the Appalachian Regional Commission to identify best practices for cleaning up waste coal piles."

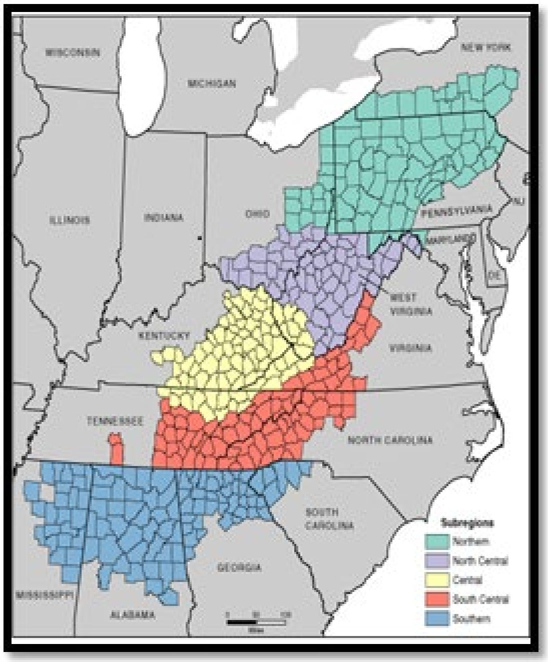
To satisfy this objective, the report Author and the Virginia Energy report team worked closely to develop key opportunities and pathways, as discussed below. The project first defined the region known as Central Appalachia (CAPP), since within this region mining technologies and practices, as well as the geologic environment, are similar, which allows for realistic comparisons of best practices.

Central Appalachian (CAPP) states are defined by the Appalachian Regional Commission (ARC) based on location and using mainly administrative borders (e.g., counties). The accepted extents of the CAPP basin are also defined by the US Geological Survey (USGS), based on major geologic features and trends. As used in other projects, some funded by the US DOE, the Author recommends adopting a definition of the CAPP basin that integrates both geological and administrative aspects by expanding the area to include adjoining/intersecting counties, while still confined within a narrow 10-mile offset. Figure 15 presents the CAPP basin of interest, including a table listing the 82 CAPP counties included in this definition.

The Karmis LLC (2022) Coal Waste Streams Report proposes the pathways below for Virginia Energy and the Commonwealth to stay in the forefront of research, practice and commercial development pertaining to gob pile utilization; to become involved in the opportunities offered by the federal bills that are aiming specifically at mined lands; and, to initiate and lead a Central Appalachian program encouraging the state agencies to share knowledge, experiences and future opportunities.

1.4.1 Evolve Central Appalachia-Research and Development Opportunities

This is an ongoing US DOE funded project, focused on expanding and transforming the use of coal and coal-based resources to produce Rare Earth Elements (REE), Critical Minerals (CM) and novel high-value, nonfuel, Carbon-Based Products (CBP). Addressing mainly waste streams produced by coal mining, it encompasses coal, coal refuse, ash, coal seam and interstitial clays/shales in storage facilities, and acid mine drainage and associated sludge. The project is executed by a public-private partnership, led by Virginia Tech. In addition, all other major universities in Central Appalachia are engaged in this project, including the University of West Virginia, the University of Kentucky, and the University of Tennessee (which participates in another partnership that cooperates with Evolve CAPP). Dr. Karmis served as the Principal Investigator for this project and Virginia Energy was included in the research team as an active project partner. Participation in this on-going project will allow Virginia Energy to stay in the forefront of research development and practice on gob piles and coal waste in general, and access and utilization in particular, including following the road to commercialization.



VCCER CAPP Counties

Kentucky (38)	Bath, Bell, Boyd, Breathitt, Carter, Clay, Elliott, Estill, Floyd, Greenup, Harlan, Jackson, Johnson, Knott, Knox, Laurel, Lawrence, Lee, Leslie, Letcher, Lewis, Madison, Magoffin, Martin, McCreary, Menifee, Montgomery, Morgan, Owsley, Perry, Pike, Powell, Pulaski, Rockcastle, Rowan, Wayne, Whitley, Wolfe
Tennessee (12)	Anderson, Campbell, Claiborne, Cumberland, Fentress, Hancock, Morgan, Overton, Pickett, Roane, Scott, Union
Virginia (8)	Buchanan, Dickenson, Lee, Norton, Russell, Scott, Tazewell, Wise
West Virginia (24)	Boone, Braxton, Cabell, Calhoun, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, McDowell, Mercer, Mingo, Nicholas, Pocahontas, Putnam, Raleigh, Randolph, Roane, Summers, Upshur, Wayne, Webster, Wyoming

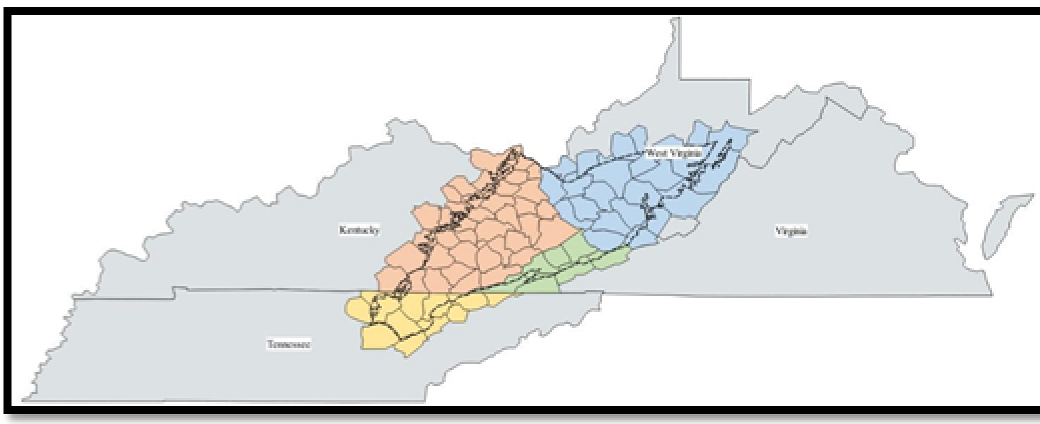


Figure 15: CAPP Definition Integrating Administrative Units (counties per ARC) and Geologic Coal Regions (USGS)

1.4.2 Clean Energy Demonstration Program on Current and Former Mine Land – Demonstration Scale Project Opportunities

The Bipartisan Infrastructure Law included $500 million for demonstrating the technical and economic viability of carrying out clean energy projects on current and former mine land across America. The funding for this program includes up to five clean energy demonstration projects in geographically diverse regions, two of which must be solar, with a goal of replication across the country and the creation of jobs and economic opportunity for current and former mining communities. The Office of Clean Energy Demonstrations of the US DOE, has planned three workshops to further inform the communities and stakeholders about this program in preparation for a future funding opportunity announcement. Karmis LLC and Virginia Energy participated in the first workshop under this program, organized by the Oak Ridge National Laboratory in Knoxville, Tennessee, September 20-21, 2022. This specific solicitation is only one example, with many other funding opportunities to follow, funded by the significant investment of the federal government via a number of bills that have already prioritized future projects focused on mined lands and coal waste streams utilization. Participation in this program and attendance at the first workshop will allow Virginia Energy to assume a more active role in major research and demonstration-scale facilities that could significantly improve and propel southwest Virginia's distressed mining communities, while remediating and possibly utilizing existing gob piles and waste coal materials. In addition, positioning Virginia Energy as an active participant in the workshops and other forums sponsored by these programs will allow the agency to maintain and expand stakeholder networking, visibility and participation of funding proposals.

1.4.3 The Central Appalachian States Gob Piles Discussion – Sharing Knowledge, Opportunities, Experiences and Best Practices

Following the spirit and direction of House Bill 657/Senate Bill 120, Virginia Energy and Karmis LLC organized a meeting of the Central Appalachian state agencies that oversee gob piles in the four CAPP states. Within the region, coal mining and coal waste practices are similar, as well as environmental impacts and rehabilitation practices. In addition, in some of these states (e.g., Virginia), there are already active gob pile utilization operations that can provide valuable information to all agencies regarding experience, successes and even failures based on technical, environmental, operational, economic or other factors. The group held its first meeting on October 5, 2022, and was able to identify immediate action items to proceed forward. First, a questionnaire was developed to allow for baselines to be established and to provide experiences and examples to be shared with all agencies involved. The group has initiated discussions and is developing plans for continuing to share information into the future. For better access and impact, the Interstate Mining Compact Commission (IMCC), a "multi-state governmental organization supporting the natural resource and related environmental protection and mine safety and health interests of its member states" (http://imcc.isa.us/) was also invited to participate in these discussions. The Central Appalachian states' agencies, including Virginia Energy, are active members of this organization.

2 COAL ASH

Coal Ash is a collective term referring to any solid materials or residues (such as fly ash, bottom ash or boiler slag) produced primarily from the combustion of coal. The use of this term is often synonymous with the terms **Coal Combustion Residuals (CCR)** and also **Coal Combustion Byproducts (CCB)** (see Glossary of Terms, Appendix 2). The main difference between CCRs and CCBs is that the former involves materials generated from burning coal for the purpose of generating electricity by electric utilities and independent power producers, whereas the latter includes both CCR and other non-CCR wastes, produced by coal combustion in other industries.

The scope of the Karmis LLC (2022) Coal Waste Streams Report is confined to the CCRs, per the mandate of the legislation.

2.1 Coal Ash – Definitions and Ash Classes

CCR Storage Facilities are structures, other appurtenances, and improvements on the land, used for treating, storing, disposing, or otherwise conducting solid waste management of CCR. They can include ash ponds, impoundments or landfills (see Appendix 2). The stored material may be segregated by particle size and discharge location.

Fly ash is removed from the power plant exhaust gases, primarily by electrostatic precipitators, baghouses or wet scrubbers. Physically, it is a fine, powdery material, composed mostly of spherical silica particles. It is a pozzolan, i.e., has cementitious properties and may serve as a replacement for cement. **Bottom ash** consists of larger gray/black particles that can be used as an aggregate, as feed stock for cement manufacturing or in construction applications to replace traditional constituents, such as sand or gravel.

The last term to be addressed is **Loss of Ignition** (LOI), a measurement of unburned carbon remaining in fly ash that is a critical characteristic for using fly ash in concrete. The carbon level found in coal combustion products (primarily fly ash) is determined in accordance with ASTM C311. Fly ash is categorized by ASTM C618 and AASHTO M 295 as **Class C** or **Class F**. Class C fly ash contains greater amounts of calcium, higher than Class F fly ash. Class C fly ash is both pozzolanic and cementitious and, when exposed to water, reacts and hardens. Class F fly ash often contains less calcium oxide (CaO) and may have a higher carbon content than Class C fly ash. In order for fly ash to be a viable alternative as a supplemental cementitious material, processing may be required to remove impurities and produce mixes that can meet current performance standards.

2.1.1 Ownership and Access

CCRs are typically produced by the generating plant and ownership is maintained by the utility or industrial plant owners. In Virginia, the two primary owners of generating power plants have been Dominion Energy and American Electric Power and its Virginia based affiliate Appalachian Power Company. The Old Dominion Electric Cooperative, through direct ownership or co-ownership, operates three power generation facilities in Virginia and Maryland. There are also a limited number of small industrial boilers that generate electricity and steam for industrial plants. In order to initiate a remediation, harvesting or beneficial use project, the owner of the site must participate in the process. The current regulatory status of the storage or disposal unit may impact whether the owner desires to access the facility unit.

The CCR generation and deposits that remain in Virginia are located at the power plant sites and ownership remains with the primary power plant owner. In order to beneficially use the CCRs, the closure status must be known, and it is important to understand the impacts on the closure or post-closure care status.

In Virginia, CCR disposal or storage units are under legislative mandate to remove the CCRs from the existing units and either beneficially use the CCR in an encapsulated use or dispose of the CCRs into a facility unit meeting the current design and performance standards of Virginia DEQ. Dominion Energy and American Electric Power control the ownership and access to the CCR resources; therefore, efforts to remove the CCRs should be coordinated with the utilities and all parties that will be impacted by the projects associated with the removal/use projects.

2.1.2 Applicable Regulation and Closure

The foundations of coal ash regulation are found in various state solid waste laws and regulations, as states normally regulated solid wastes while the federal agencies' rules governed hazardous and toxic wastes. At the federal level, the origin for coal ash regulations was initially included in the Resource Conservation and Recovery Act (RCRA) of 1976. RCRA was enacted after a series of hazardous and toxic waste open dump activities drew national attention. In RCRA, Subtitle C was aimed at hazardous waste management.

Congress gave legislative clarity to questions related to coal ash management by passing a RCRA Amendment in 1980, known as the Bevill Amendment, which directly addressed coal ash. The Bevill Amendment formalized the mandate for EPA to study coal ash and make a recommendation or determination on whether coal ash should be regulated as hazardous waste. EPA was instructed to report back to Congress within two years.

At the legislative level, Congress again amended RCRA in 1984 with the Hazardous and Solid Waste Amendments (HSWA) to add subtitle D, which prohibits "open dumps" and established a program applicable to the disposal of nonhazardous waste. Subtitle D targeted non-hazardous waste management including non-hazardous industrial wastes and municipal solid wastes.

As instructed by the Bevill Amendment, EPA investigated the coal ash regulation issue and reported on its determinations in 1988, 1993, and 2006, all stating that coal ash should not be regulated as hazardous waste under RCRA subtitle C. In 2000, EPA also said that it intended to regulate coal ash waste as nonhazardous under subtitle D.

EPA regulation activities had not developed final rules by the time the surface impoundment dike at the Tennessee Valley Authority's (TVA) Kingston generating plant failed in December 2008, releasing 5.4 million cubic yards of coal ash. EPA stepped up its efforts to regulate coal ash after the Kingston incident. In 2010, EPA proposed new rules for regulating coal ash as non-hazardous under RCRA-Subtitle D. After a protracted rule development process and broad-based public input, EPA issued the final rules for coal ash management in 2015.

The 2015 EPA coal ash regulation established minimum national criteria for Coal Combustion Residuals (CCR) managed in surface impoundments, landfills or open dumps. The goal was to eliminate surface impoundments as a method to manage CCRs unless the impoundments were upgraded to the new criteria. Because of court challenges the deadlines for closure of impoundments and landfill impacts were subject to moving target deadlines. The 2015 rule applied directly to applicable facilities and was self-implementing prior to the Water Infrastructure Improvements for the Nation Act of 2016 (WIIN).

Under RCRA Subtitle C, EPA's national criteria enforcement and permitting responsibility remained at the federal level until a state hazardous waste program was authorized. The original RCRA granted authority to EPA over hazardous wastes under Subtitle C and states were allowed to request program authority for hazardous waste management. States had control of Subtitle D non-hazardous waste programs. Congress sought to clarify the enforcement and management issues with the passage of the WIIN Act which granted EPA authority for permitting and enforcement of CCRs which were traditionally a Subtitle D waste. The WIIN Act established a framework for states to develop their own equivalent or more stringent CCR programs and seek authority to administer the federal minimum program with permits and enforcement. If states did not request and receive authorization, then EPA can continue to issue permits and enforce the national minimum criteria.

Since the passage of WIIN, only a select number of states have sought authorization. Some states, including Virginia, took actions to pass legislation to address CCRs. The Virginia DEQ in 2016 adopted the federal CCR criteria rules into State regulations. Virginia also passed legislation in July 2019 to establish very specific CCR management actions regarding utility facilities that have CCR impoundments or landfills.

2.1.3 Virginia CCR Regulation/Legislation

Virginia's General Assembly enacted coal ash legislation (Senate Bill 1355) in July 2019, effectively prohibiting closure by leaving CCR in place (cap-in-place). Senate Bill 1355 requires that all inactive CCR units located at named generating stations owned by Dominion Energy be closed by removing all CCR in accordance with Virginia DEQ standards. Removed CCRs must be either beneficially reused or disposed of in a permitted landfill, either on-site or off-site. Landfills which accept the removed CCRs must have a composite liner and leachate collection system that meets or exceeds EPA's national minimum criteria. The Code was modified in 2020 to add similar language for CCR management units in other parts of the Commonwealth.

Section 10.1-1402.03 of the Virginia Code titled *Closure of Certain Coal Combustion Residuals Units* states that:

> The owner or operator of any CCR unit located within the Chesapeake Bay watershed at the Bremo Power Station, Chesapeake Energy Center, Chesterfield Power Station, and Possum Point Power Station that ceased accepting CCR prior to July 1, 2019, shall complete closure of such unit by (i) removing all of the CCR in accordance with applicable standards established by Virginia Solid Waste Management Regulations (9VAC20-81) and (ii) either (a) beneficially reusing all such CCR in a recycling process for encapsulated beneficial use or (b) disposing of the CCR in a permitted landfill on the property upon which the CCR unit is located, adjacent to the property upon which the CCR unit is located, or off of the property on which the CCR unit is located, that includes, at a minimum, a composite liner and leachate collection system that meets or exceeds the federal Criteria for Municipal Solid Waste Landfills pursuant to 40 C.F.R. Part 258. The owner or operator shall beneficially reuse a total of no less than 6.8 million cubic yards in aggregate of such removed CCR from no fewer than two of the sites listed in this subsection where CCR is located.

The Virginia law also states that:

> Encapsulated beneficial use means a beneficial use of CCR that binds the CCR into a solid matrix and minimizes its mobilization into the surrounding environment.

Note that the allowed beneficial uses are more restrictive than the federal rules. The timetable established by the law states that:

> …the owner or operator shall complete the closure of any such CCR unit required by this section no later than 15 years after initiating the closure process at that CCR unit.

Virginia Code Section 10.1-1402.04 titled *Closure of Certain Coal Combustion Residuals Units; Giles and Russell Counties* was added in 2020 to address remaining facilities in Virginia, primarily two facilities owned by American Electric Power. The law states that:

> The owner or operator of any CCR unit located in Giles County or Russell County at the Glen Lyn Plant and the Clinch River Plant shall, if all CCR units at such plant ceased receiving CCR and submitted notification of completion of a final cap to the Department prior to January 1, 2019, complete post-closure care and any required corrective action of such unit. If all CCR units at such plant have not submitted notification of completion of a final cap to the Department prior to January 1, 2019, the owner or operator shall close all CCR units at such plant by (i) removing all of the CCR in accordance with applicable standards established by Virginia Solid Waste Management Regulations (9VAC20-81) and (ii) either (a) beneficially reusing all such CCR in a recycling process for encapsulated beneficial use or (b) disposing of the CCR in a permitted landfill on the property upon which the CCR unit is located, adjacent to the property upon which the CCR unit is located, or off of the property on which the CCR unit is located, that includes, at a minimum, a composite liner and leachate collection system that meets or exceeds the federal Criteria for Municipal Solid Waste Landfills pursuant to 40 C.F.R. Part 258.

> The owner or operator shall beneficially reuse CCR removed from its CCR unit if beneficial use of such removed CCR is anticipated to reduce costs incurred under this section.

Due to potential community traffic impacts, Senate Bill 1355 required the utility to prepare a transportation plan in consultation with each county, city, or town within two miles of the CCR site in order to (1) minimize traffic impact on surrounding communities, and (2) use a mix of transportation options, including rail and barge, when possible, as needed to meet the closure timeframe.

Dominion Energy prepared a report summarizing responses to its Request for Proposals for bids on beneficial use and closure projects for each of its coal generation stations. The report's summary included the chart shown in Figure 16 (below), which indicates the transportation requirements for typical projects removing and transporting CCR to either a disposal or a beneficiation plant.

Senate Bill 1355 also provides a pathway for utilities' recovery of costs associated with closing the applicable CCR units. Closure costs are recoverable through a rate adjustment clause authorized by the State Corporation Commission. The law caps the utility costs for closure at $225 million per year annually through the rate adjustment clause. Recoverable costs are to be allocated to the Virginia customer base.

Power Station	Transportation Options	Vehicle Volume	Project Duration (Years)
Bremo Power Station	Truck	124 to 161 Trucks/day	10 to 11
	Rail	270 Railcars/year	14
Chesapeake Energy Center	Truck	65 to 143 Trucks/day	5 to 11
	Truck + Rail	20 Trucks/day + 67 Railcars/year	11
	Barge	Up to 5 Barges/year	10
Chesterfield Power Station	Truck	278 to 300 Trucks/day	15
	Truck + Rail	34 Trucks/day + 260 Railcars/year	13
	Rail	2,500 to 3,750 Railcars/year	15
Possum Point Power Station	Truck	105 to 114 Trucks/day	7 to 11
	Rail	232 Railcars/year	10

Figure 16: Transportation requirements for typical projects removing and transporting CCR to either a disposal or a beneficiation plant (Source: Dominion Energy, 2017)

2.2 Location of CCR Facilities in the Commonwealth

CCRs facilities in the Commonwealth are listed in Table 1 and Table 2, using the comprehensive databases of the Virginia Department of Environmental Quality. Detailed locations and area maps for each CCR storage facility cited are also included in Appendix 8.

Table 2: DEQ Region, Facility name, Status, County, Permit, Permit Status, Unit Name

DEQ Region	Facility Name	Status	City/County	Permit	Permit Status	Unit Name
SWRO	American Electric Power - Clinch River Plant	The facility ceased burning coal in 2015 and still generates power from 2 gas fired steam turbines.	Russell County	SWP620	Permitted	Ash Pond 1
SWRO	American Electric Power - Clinch River Plant	The facility ceased burning coal in 2015 and still generates power from 2 gas fired steam turbines.	Russell County	SWP624	Permitted	Ash Pond 2
SWRO	American Electric Power - Clinch River Plant	The facility ceased burning coal in 2015 and still generates power from 2 gas fired steam turbines.	Russell County	SWP223	Permitted	Appalachian Power-Clinch Riv P
BRRO-R	APCO - Glen Lyn	Glen Lyn plant ceased operation summer 2015 (before Oct 19, 2015 effective date)	Giles County	SWP222	Permitted	Appalachian Power -Glen Lyn Pl
BRRO-R	APCO - Glen Lyn	Glen Lyn plant ceased operation summer 2015 (before Oct 19, 2015 effective date)	Giles County	SWP222	Pending	Auxiliary Fly Ash Pond
BRRO-R	APCO - Glen Lyn	Glen Lyn plant ceased operation summer 2015 (before Oct 19, 2015 effective date)	Giles County	SWP222	Pending	West Pond
BRRO-R	APCO - Glen Lyn	Glen Lyn plant ceased operation summer 2015 (before Oct 19, 2015 effective date)	Giles County	SWP621	Pending	Bottom Ash Pond
VRO	Dominion - Bremo Power Station	In 2014, the power station converted from a coal-fired power plant to a natural gas power plant.	Fluvanna County	SWP618	Permitted	North Ash Pond
VRO	Dominion - Bremo Power Station	In 2014, the power station converted from a coal-fired power plant to a natural gas power plant.	Fluvanna County	SWP618	Permitted	East Ash Pond
VRO	Dominion - Bremo Power Station	In 2014, the power station converted from a coal-fired power plant to a natural gas power plant.	Fluvanna County	SWP618	Permitted	West Ash Pond
TRO	Dominion - Chesapeake Energy Center	Coal-fired boilers shut down Dec 2014; Center continues to produce electricity from other fuels	Chesapeake City	SWP440	Permitted	Dominion Virginia Power - Ash Landfill
TRO	Dominion - Chesapeake Energy Center	Coal-fired boilers shut down Dec 2014; Center continues to produce electricity from other fuels	Chesapeake City	SWP440	Permitted	Bottom Ash Pond
NRO	Dominion - Possum Point Power Station	The facility ceased burning coal in 2003. The power station continues to produce electricity from four generating units using other fuels	Prince William County	SWP617	Permitted	Pond ABC
NRO	Dominion - Possum Point Power Station	The facility ceased burning coal in 2003. The power station continues to produce electricity from four generating units using other fuels	Prince William County	SWP617	Permitted	Pond D
NRO	Dominion - Possum Point Power Station	The facility ceased burning coal in 2003. The power station continues to produce electricity from four generating units using other fuels	Prince William County	SWP617	Permitted	Pond E
SWRO	Dominion - VA City Hybrid Energy Center Landfill	Operational - burning coal	Wise County	SWP608	Permitted	Curley Hollow Industrial Landfill
TRO	Dominion - Yorktown Power Station	Coal burning units shutdown Mar 2019; limited use oil burning unit remainsn operational	York County	SWP457	Permitted	Virginia Electric and Power Co - Industrial LF
PRO	Dominion Energy - Chesterfield Power Station	Operational - burning coal, coverted to dry ash management	Chesterfield County	SWP609	Permitted	FFCP Management Facility
PRO	Dominion Energy - Chesterfield Power Station	Operational - burning coal, coverted to dry ash management	Chesterfield County	SWP619	Pending	Lower (West) Pond
PRO	Dominion Energy - Chesterfield Power Station	Operational - burning coal, coverted to dry ash management	Chesterfield County	SWP619	Pending	Upper (East) Pond
BRRO-R	Dominion/ODEC - Clover Power Station	Operational - burning coal	Halifax County	SWP622	Permitted	Sludge Stabilization Basins (North and South)
BRRO-R	Dominion/ODEC - Clover Power Station	Operational - burning coal	Halifax County	SWP556	Permitted	Stages 1/2
BRRO-R	Dominion/ODEC - Clover Power Station	Operational - burning coal	Halifax County	SWP556	Permitted	Stage 3

Table 3: DEQ Region, Facility name, Unit type, Acres, Volume, Unit Status, Comments …

DEQ Region	Facility Name	Unit Type	Area (acres)	Volume (cy)	Unit Status	Comments	EPA Rule	DEQ WMA
SWRO	American Electric Power - Clinch River Plant	Surface Impoundment	22.0	2,110,000.00	Post-Closure	Closure in place; CCR Rule final cover; 30 yr PCC began Aug 2018	Y	10.1-1402.04
SWRO	American Electric Power - Clinch River Plant	Surface Impoundment	25.0	1,930,000.00	Post-Closure	Closure in place under VPDES permit; 30 yr PCC began Feb 2014	N	10.1-1402.04
SWRO	American Electric Power - Clinch River Plant	Industrial Landfill	24.0	1,000,000.00	Post-Closure	Ceased waste receipt 10/14/2015; Certified closed Oct 2018; 30 yr PCC began Oct 2018	N	10.1-1402.04
BRRO-R	APCO - Glen Lyn	Industrial Landfill	33.0	1,077,110.00	Post-Closure	Certified closed; 10 yr PCC period began Dec 2011; To be removed pursuant to WMA	N	10.1-1402.04
BRRO-R	APCO - Glen Lyn	Surface Impoundment	12.0	303,845.00	Post-Closure	Certified closed; 10 yr PCC period began Dec 2014; To be removed pursuant to WMA	N	10.1-1402.04
BRRO-R	APCO - Glen Lyn	Surface Impoundment	5.0	460,000.00	Inactive	Inactive. To be closed by removal pursuant to WMA	N	10.1-1402.04
BRRO-R	APCO - Glen Lyn	Surface Impoundment	6.0	160,000.00	Inactive	Inactive. To be closed by removal pursuant to WMA	N	10.1-1402.04
VRO	Dominion - Bremo Power Station	Surface Impoundment	67.5	4,000,000.00	Inactive	Inactive. Received ash from East and West Ponds. To be closed by removal pursuant to WMA	Y	10.1-1402.03
VRO	Dominion - Bremo Power Station	Surface Impoundment	27.0		Ash Removed	July 2019 CQA Report certifying CCR removal, over excavation + visual inspection; GW monitoring on-going	Y	10.1-1402.03
VRO	Dominion - Bremo Power Station	Surface Impoundment	22.0		Ash Removed	March 2020 CQA Report certifying CCR removal, over excavation + visual inspection; GW monitoring on-going	Y	10.1-1402.03
TRO	Dominion - Chesapeake Energy Center	Industrial Landfill	23.0	937,000.00	Inactive	Ceased accepting CCR prior to October 19, 2015. To be closed by removal (including historical fill underneath the landfill) pursuant to WMA	N	10.1-1402.03
TRO	Dominion - Chesapeake Energy Center	Surface Impoundment	4.6	41,250.00	Inactive	Inactive. To be closed by removal pursuant to WMA	Y	10.1-1402.03
NRO	Dominion - Possum Point Power Station	Surface Impoundment	18.0		Ash Removed	June 2019 CQA Report certifying CCR removal, over excavation + visual inspection; GW monitoring on-going	Y	10.1-1402.03
NRO	Dominion - Possum Point Power Station	Surface Impoundment	64.0	4,400,000.00	Inactive	Inactive. Received ash from Ponds ABC and E. To be closed by removal pursuant to WMA	Y	10.1-1402.03
NRO	Dominion - Possum Point Power Station	Surface Impoundment	38.0		Ash Removed	June 2019 CQA Report certifying CCR removal + visual inspection; GW monitoring on-going	Y	10.1-1402.03
SWRO	Dominion - VA City Hybrid Energy Center Landfill	Industrial Landfill	160.0	35,000,000.00	Active	Existing LF Active	Y	N/A
TRO	Dominion - Yorktown Power Station	Industrial Landfill	48.0	1,762,000.00	Post-Closure	Closure in place; CCR Rule final cover; 30 yr PCC began Aug 2020	Y	N/A
PRO	Dominion Energy - Chesterfield Power Station	Industrial Landfill	66.0	9,361,333.00	Active	New CCR Landfill, constructed w Sub D liner	Y	N/A
PRO	Dominion Energy - Chesterfield Power Station	Surface Impoundment	111.0	2,800,000.00	Inactive	Inactive. To be closed by removal pursuant to WMA	Y	10.1-1402.03
PRO	Dominion Energy - Chesterfield Power Station	Surface Impoundment	113.0	11,800,000.00	Inactive	Inactive. To be closed by removal pursuant to WMA	Y	10.1-1402.03
BRRO-R	Dominion/ODEC - Clover Power Station	Surface Impoundment	4.0	38,000.00	Active	Retrofit to Sub D liner [North completed Aug 2018; South completed Nov 2019] Basins drained and CCR removed to LF on routine basis	Y	N/A
BRRO-R	Dominion/ODEC - Clover Power Station	Industrial Landfill	26.0	2,300,000.00	Post-Closure	Unit closed in 1993; not subject to CCR Rule	N	N/A
BRRO-R	Dominion/ODEC - Clover Power Station	Industrial Landfill	80.0	8,000,000.00	Active	Existing LF Active	Y	N/A

The CCR management units are in general located at utility or industrial plant sites. Utility sites which contain the largest quantity of CCRs within Virginia are normally located on the contiguous property sites at each power plant. As shown in the state site inventory list the locations are at the plants and the owner of the plant retains ownership of the CCR site. Large CCR sites in the eastern part of Virginia are owned by Dominion Electric and large sites in the western side of Virginia are in general owned by AEP. Under the Virginia legislation, each of the larger CCR sites are addressed by name with specific criteria and requirements for how the CCRs are to be mitigated at facility units that are not in compliance with the applicable protective standards for units.

2.3 Beneficial Utilization of Coal Ash

Coal ash is a general term, referring to the waste material left over after coal combustion. In the case of a coal fired power plant, the combustible material includes fly ash and bottom ash. When the organic material was deposited approximately 50 million years ago, minerals such as natural erosion soils deposited with the plants and natural minerals taken up within the organic plants created the mineral portion of each coal deposit. Ash content is the measure of mineral content of a particular coal deposit and ash content varies depending on each coal deposit formation. When coal is combusted, the organic portion of coal ignites and generates heat, which was used for home heating for centuries or for generation of electricity in more recent decades. During the combustion process the non-combustible minerals remain as ash.

2.3.1 Characterization

In industrial applications such as electricity generation, coal ash is normally divided into two categories based on particle size and where it is collected after combustion of the organic matter. Fly ash is the fine-particle mineral matter usually entrained in the exhaust gas and is carried out of the combustion chamber or boiler and collected in pollution control devices. Bottom ash is the coarse particle minerals, and it falls to the bottom of the combustion chamber or boiler and is collected as a granular aggregate and removed from the bottom of the boiler. Depending on the efficiency of the combustion process for particular boilers, the coal ash may contain small amounts of unburned organic matter coal.

Fly ash is the most voluminous constituent of coal ash, making up typically 70-90% by weight of the total coal ash. Bottom ash is the coarse component of coal ash, often comprising about 10% to 30% of the mineral byproduct. The composition of fly ash and bottom ash varies depending on a number of factors, such as coal composition, boiler type, and combustion conditions. Elemental compositions of coal ash samples reported in the literature are summarized in Appendix 9. Samples collected from survey and characterization activities require different types of characterization (see Appendix 9, Table 9). Results of these characterizations can often indicate the potential for coal fly ash or bottom ash to be used beneficially, for construction materials or alternate applications.

2.3.2 Production of Construction Materials

Coal ash, also referred to as coal combustion residues or CCRs, is produced primarily from the burning of coal in coal-fired power plants. Coal ash is one of the largest types of industrial byproducts generated in the United States. According to the American Coal Ash Association's Coal Combustion Product Production & Use Survey Report (ACAA, 2020), about 69 million tons of coal combustion products were generated in 2020. This included 42.5 million tons of coal ash and the remainder were flue gas desulfurization byproducts. ACAA reports that about 60% of the reported coal ash was beneficially used. Construction materials is a typical use of coal ash (see Appendix 10, Table 10). Fly ash is utilized for both encapsulated applications and non-encapsulated applications. A primary encapsulated use is as a supplementary cementitious additive to ready-mixed concrete and as a kiln feed input for cement clinker manufacturing. Non-encapsulated uses include structural fills or embankments or land-based applications where the fly ash remains unchanged by the application. It is noteworthy that the definition of encapsulated uses differs in Virginia rules and laws versus federal CCR regulations under EPA.

ASTM C618 gives detailed standard specifications for coal ash for use in concrete. The chemical requirements and physical requirements are shown in Appendix 10, Table 11 and Table 12, respectively. Based on the standard specifications, the loss on ignition (LOI) of Class F and C ashes needs to be less than 6.0%. In addition, the fraction of particles coarser than 45 µm in the three classes of fly ash should be less than 34%. While the ASTM C618 standard for fly ash use in concrete limits the LOI to 6.0%, the market actually requires the LOI at lower levels, typically limiting it to no more than 3% in most states and regions. The only place where LOIs are acceptable in the 5% range is Florida, where air entrainment is not needed. If air entrainment admixtures are needed, the LOIs above 3-4% add more expense and the end users (the market) do not accept high LOI fly ash due to the economic impacts of the admixtures. Consequently, while the ASTM specs may allow higher LOIs, the market costs drive the decisions of the user and high LOIs are not in demand. Although there have been recent efforts by AASHTO and ASTM to harmonize LOI limits, Departments of Transportation (DOT) restrict LOI used in concrete to levels as low as 2% to 3%. The Virginia DOT Road and Bridge Specifications refer to ASTM C618 which has the 6.0% limit. However, the market usually restricts the LOI to 3% for concrete used on VDOT projects, since air entrainment agents can negatively be impacted when the LOI exceeds 3%. Recent research funded by the National Highway Cooperative Research Program, has shown that coal ash, even when it does not meet current specifications, can still provide significant benefits when used in concrete (Thinley et al., 2022; Wang et al., 2022; Wang et al., 2022). Since the LOI and particle size must meet strict criteria and standards before its distribution in the market and most coal ash placed into landfills or impoundments do not meet the standards, beneficiation technologies to correct the LOI and particle size are required to re-qualify the fly ash for market uses such as concrete or cement manufacturing.

While fly ash is a valued resource for its pozzolanic characteristics when it meets quality standards for concrete specification, fly ash has many other attributions that make it beneficial as a construction material or for other applications. Fly ash typically has a very small particle size and a spherical shape, making it useful in many cases where minerals are often used in small particle applications. As an example of potential uses outside the normal cementitious area, fly ash has been used successfully as a substitute for ground calcium carbonate filler in the manufacturing of asphalt roofing shingles and commercial carpets that have a foam rubber backing. Fly ash is also used in asphalt pavement, where it replaces some asphalt binder and can improve rheological performance, damage healing, and cracking resistance (Abdalla et al., 2022; Melaku et al., 2022; Ramme et al., 2016).

Bottom ash has been used for decades in the manufacturing of concrete masonry units, often referred as “cinder blocks.” Bottom ash is more like an aggregate and can be used as a substitute for manufactured or quarried aggregates once properly sized for the particular application. In addition, bottom ash can also be ground and used as Supplementary Cementitious Materials (SCMs).

Coal fly ash also contains certain amounts of spherical particles with a hollow center, which are normally referred to as cenospheres. The concentration of cenospheres in fly ash varies over a wide range, from 0.01% to 4.8% by weight, and in most cases limited to between 0.3% and

1.5%. Due to the hollow structure, cenospheres have low apparent (0.4-0.72 g/cm^3) and bulk (0.25-0.7 g/cm^3) densities. Due to this light-weight property, cenospheres are desirable fillers in light-weight concrete, polymers, various polymeric composites, paints, and coatings. Cenospheres have a high market value due to the extensive processing required to dry, separate, collect and size the spheres to meet desired filler specifications. Even though fly ash contains only marginal concentrations of cenospheres, these hollow spheres can account for considerable value per ton. Recovering cenospheres from landfilled or impoundment coal ash is expensive and not economical in most cases.

The deposits of CCRs found in Virginia landfills and impoundments will require extensive processing to meet existing specifications for use in encapsulated-type applications as defined by Virginia law and regulations. The encapsulated requirement essentially eliminates many applications where fly ash and bottom ash are traditionally utilized. The high-volume applications that fit the definition of encapsulated in Virginia include use in concrete and manufacturing of cement clinker. The technologies required for these two uses must be capable of lowering the LOI from the elevated levels expected in the existing deposits. For cement clinker production, LOI lowering is not required as the kiln can generally combust the remaining LOI in ash. Many of the operating cement plants that can typically handle about 10% LOI. It should be noted, however, that the 10% estimate is an average LOI throughout the landfill deposits. LOIs may be higher than 16% in many portions of ash deposits, requiring a test/blend operation to achieve an acceptable LOI at the cement plant. Testing and blending operations require significant control and quality assurance.

Coal ash found in Virginia-based location deposits must be harvested from impoundments or landfills and will require various processing steps to produce a specification-grade pozzolan and generate a high-value product that qualifies for large-volume use. Since the coal ash, whether in a landfill or impoundment, will have some level of moisture (typically 15% to 20%, similar to native soils), it must be dried to remove the moisture to levels below 1% to ensure flow through mechanical handling or storage equipment. If the ash has elevated levels of unburned carbon above 3%, then a beneficiation technology process must be applied to remove the carbon particles and reduce the carbon to meet the required specification for use in VDOT approved concrete.

Depending on the unburned carbon content of fly ash, processing can proceed by applying one of two separate general technical routes: a dry route or a wet route. A detailed discussion of fly ash dry processing is presented in Appendix 10. Based on the results of prior studies, an efficient dry processing flowsheet for fly ash can be developed. One dry process is shown in Figure 17. In this process, dried fly ash is first separated into fine and coarse fractions, which are then separately subjected to triboelectrostatic separation. Depending on whether large agglomerates exist, fly ash may need to be pulverized before size classification to break the agglomerates. In triboelectrostatic separation, carbon particles are separated from mineral particles. The dried mineral fly ash with the lower LOI can be used for concrete applications, while the carbon-rich material removed is either reused as a fuel or disposed of as a waste material. Multiple stage processing can be added for more problematic elevated LOI fly ash.

Fly ash with elevated LOI can also be processed using a wet separation process sometimes referred to as carbon flotation. Carbon particles are usually lighter in weight than the mineral fly ash particles and, with the proper reagent added to enhance the carbon particle floatation, a wet process can successfully lower the fly ash LOI. The floatation-separated fly ash mineral must be dewatered and dried to produce saleable products which can be used as pozzolan. A wet separation or flotation process is shown in Figure 18.

Wet processes may be more suitable for processing fly ash with high moisture content. Different wet separation technologies are available to recover valuable components from fly ash, such as froth flotation to recover unburned carbon (Zhang & Honaker, 2015) and reflux classification to recover cenospheres and low-density materials (Kiani et al., 2015). In this process, unburned carbon is first recovered through column flotation, and then the decarbonized material is fed to a reflux classifier. Coarse and light particles are reported to the overflow, and after being processed in an inverted reflux classifier, the particles are separated into two products, namely cenospheres (<1 g/cm^3) and low-density materials (1-1.3 g/cm^3). The underflow of the reflux classifier is primarily comprised of fine and heavy particles. To further ensure that the particle size of this stream is correct, the underflow is fed to a sieving step to remove coarse particles, leading to a pozzolan product. All the products need to be dewatered and dried to meet moisture content requirements.

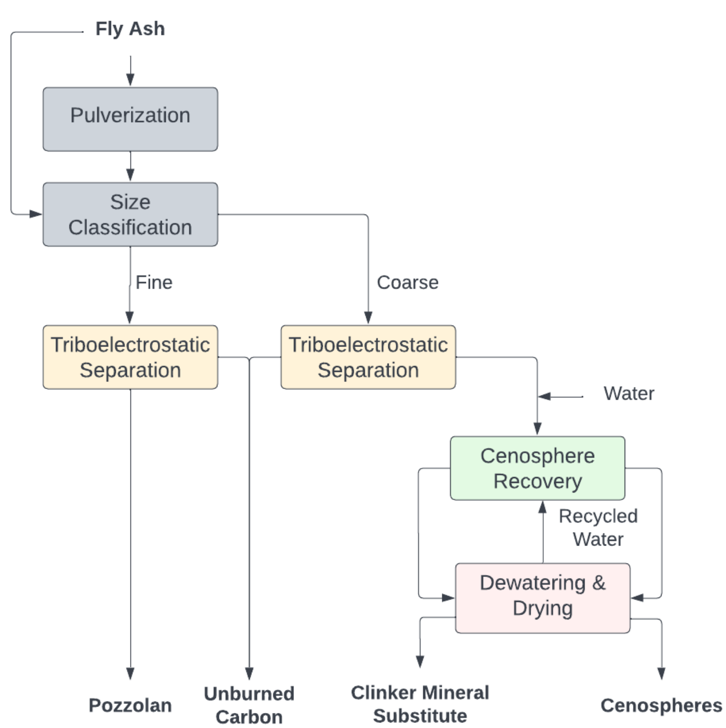


Figure 17: Construction material production from fly ash through a dry process

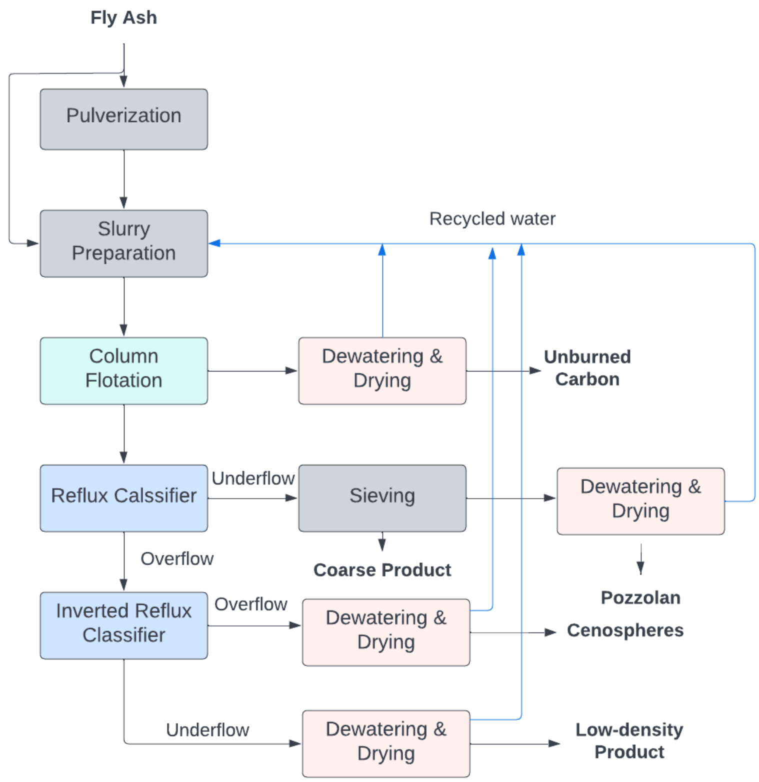


Figure 18: Construction material production from fly ash through a wet process

2.3.3 Production of Critical Minerals

Most of the critical minerals existing in coal are transported to coal ash after combustion. In addition, the critical mineral content in coal ash is much higher than coal since the majority of the organic matter is eliminated during combustion. Therefore, coal ash is a more promising feedstock for critical mineral recovery than coal, in terms of the higher critical element content. In addition, studies have shown that Appalachian Basin coals have elevated levels of critical minerals which then concentrate in the coal ash. Since Virginia utilities have utilized more Appalachian Basin coals due to proximity, it is expected that coal ash deposits at Virginia utility sites should have higher concentrations of critical minerals. Typically, coal ash deposits at utility sites using western coals usually contain lower concentrations of critical minerals.

The inorganic matter in coal however, goes through significant physical and chemical changes during combustion due to the high temperature (e.g., 1,400°C). In this case, a significant amount of amorphous silicate and aluminosilicate are formed, which are glassy and difficult to dissolve. A number of studies have reported that the majority of Rare Earth Elements (REEs) in coal fly ash are associated with silicates and aluminosilicates. As a result, the leachability of

REEs from coal fly ash is normally low, and in order to achieve satisfactory recovery, coal fly ash can be pretreated using appropriate methods, such as alkaline treatment and roasting.

One of the most efficient methods to reduce the critical mineral recovery cost is improving the critical mineral content in coal ash. For example, assuming the same operating conditions are applied, the recovery cost can be reduced by 50% when the critical mineral content in the feedstock is doubled. Physical separations, such as size classification, magnetic separation, and gravity separation have been performed on coal ash to enrich critical minerals. For example, studies reported in the literature found that REEs in coal fly ash tend to be concentrated in fine and non-magnetic fractions.

Based on the above discussion, it can be concluded that the best way to maximize the utilization of coal ash is to use physical separations to separate coal ash into products that are enriched and depleted of critical minerals, respectively. The product rich in critical minerals can be used as a feedstock for downstream critical mineral recovery, while the product with low critical mineral content can be used for producing construction materials (see Figure 19). More details about critical mineral recovery from coal ash are provided in Appendix 11, Table 13.

A technical roadmap for critical mineral recovery from coal combustion ash is shown in Figure 20.

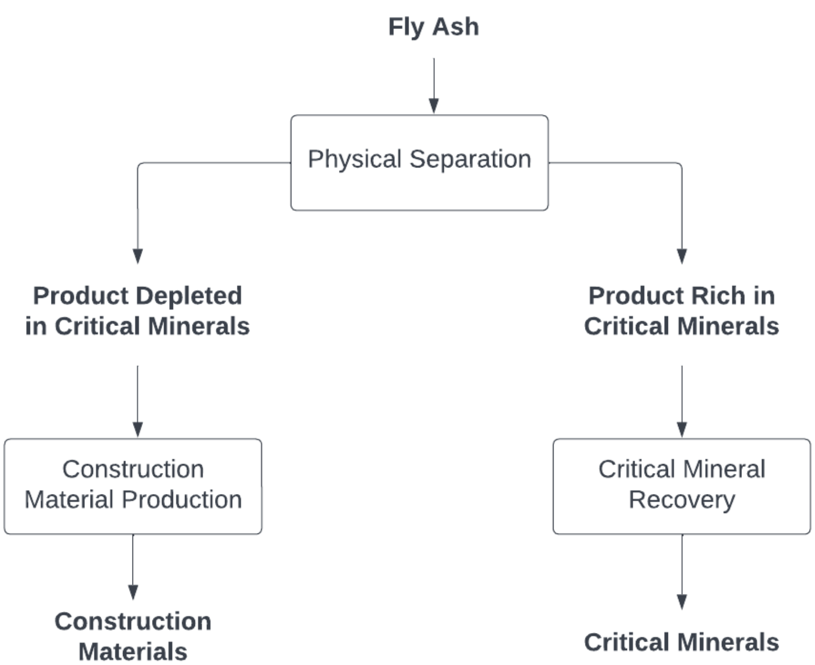


Figure 19: A promising scenario to maximize the utilization of coal fly ash

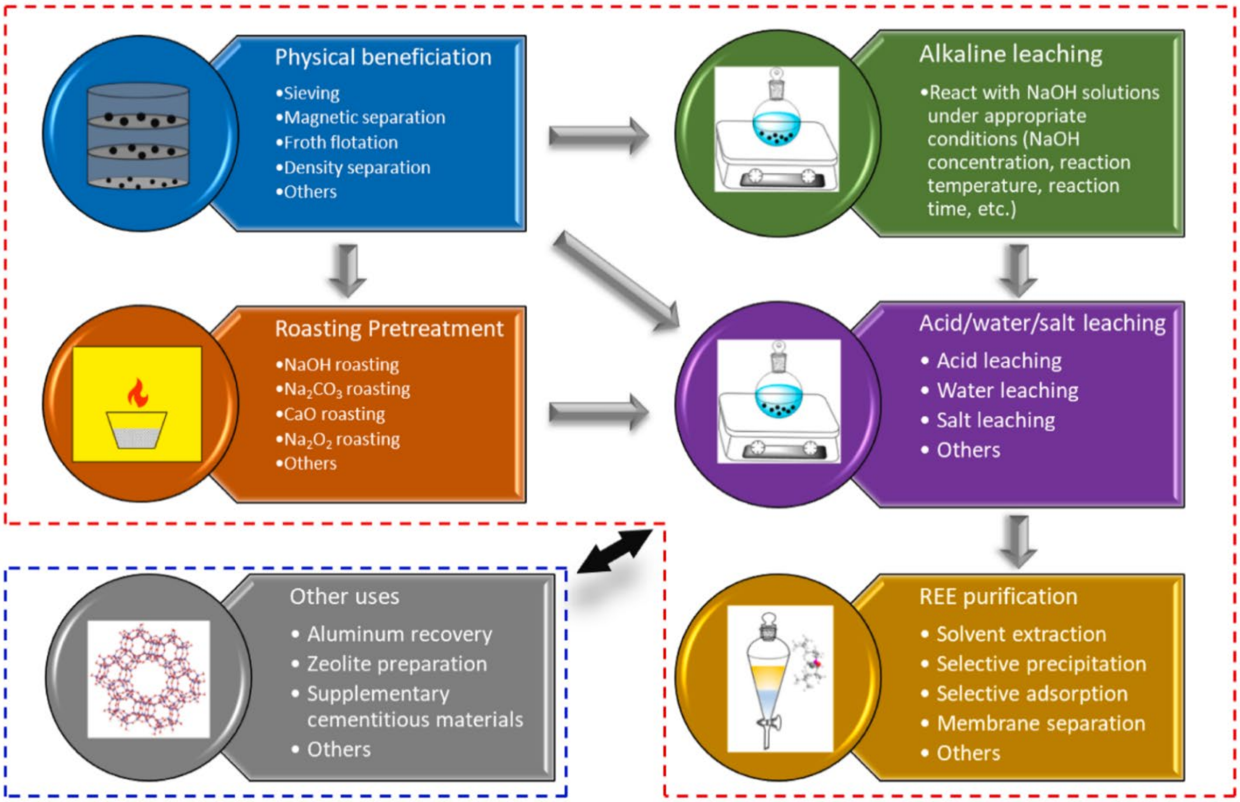


Figure 20: Technical roadmap for critical mineral recovery from coal combustion ash formulated based on findings from existing studies reported in the literature (Fu et al., 2022)

2.4 Coal Ash Facility Closure

Closure of a CCR facility unit is subject to specific federal and state guidelines within the EPA's CCR Rule and the Virginia Solid Waste Management Regulations. CCR Site closures also have the over-arching criteria that any industrial property has when undergoing a closure by removal (sometimes referred to as "clean closure") that would allow return of the property use to un-restricted applications driven by either market conditions or regulatory health and safety requirements. Closure plans certified by a Professional Engineer, or the state are required for CCR facility unit closure.

EPA rules establish that closure by removal of the CCRs meets the following. An owner or operator may close a CCR unit by removing and decontaminating all areas affected by releases from the CCR unit. Removal and decontamination are complete when constituent concentrations throughout the CCR unit and affected areas have been removed and groundwater monitoring concentrations are less than the applicable groundwater protection standards.

To achieve a successful clean closure under the CCR regulations, the unit owner/operator must remove all CCRs and soils that contacted the CCRs. Subsequent to the removal of all CCRs and contact soils that underlie the CCR deposits, a soil testing program must document that the underlying soils are clean and free of contact impacts from CCRs.

Groundwater monitoring of the underlying uppermost aquifers must demonstrate that CCR impacts to groundwater, if any have occurred, are mitigated by the CCR deposit removal. The requirements embedded in the CCR criteria and regulations will lead to a site environmental assessment that can allow the property to be gainfully utilized for further development purposes and comply with a normal property environmental assessment process accepted by the broader real estate industry.

2.5 Coal Ash Storage Facilities as Potential Sites for Constructing Public Infrastructure Projects

House Bill 657/Senate Bill 120 have not provided specific guidance on the type of public infrastructure projects to be considered as candidates for remediated coal ash sites. The emphasis of this section of the report, therefore, was placed on the steps required to evaluate and permit such sites for potential development.

The environmental condition of land can be evaluated through professional assessments before constructing infrastructure on the land. The assessment is normally conducted through three phases: Phase I Environmental Site Assessment (ESA), Phase II ESA, and Phase III ESA. The Phase I ESA is generally considered the first step in the process of environmental due diligence. The US EPA has formulated standards for performing Phase I ESA, which are based in part on the ASTM E1527 standard. The physical state of the land is investigated first during a Phase I assessment. For example, environmental engineers walk through the property, looking for any evidence of wells, chemicals, spills, or anything else that might indicate previous use of contaminants. A Phase I assessment also usually involves a review of the historical records and other evidence relating to the land’s prior uses. A Phase I assessment also typically includes a search of state and federal environmental databases. Some other activities are included in a Phase I assessment, which can be found in EPA standard and the ASTM E1527 standard. If the property has or has had in the past a known deposit of CCRs then a Phase I ESA results in movement to a Phase II process immediately.

If a site, or nearby site, is identified as potentially contaminated land, a Phase II assessment is required, which goes deeper into the onsite conditions including solids, air, and water on the facility. A Phase II assessment involves collecting and analyzing soil, air, or water samples. The results of these tests help determine the extent of contamination and any needed remediation steps, such as soils clean-up or water decontamination. A Phase II assessment must be conducted per the ASTM E1903 standard, “Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process.” This standard specifies procedures based on the scientific method to characterize property conditions using objective, representative, reproducible, and defensible methods. This standard provides detailed instructions for sampling and chemical analysis procedures.

If land is identified as contaminated, a Phase III assessment, also known as Remediation Investigations/Feasibility Studies, is a necessary step in the environmental remediation process for contaminated land. A Phase III assessment normally includes identifying the extent of contaminants found during the Phase II assessment, determining the amount of soil and groundwater impacted by the environmental contaminants, submitting a proper notification to regulatory agencies and completing a site notification report, developing a remediation action plan to remove contaminants, and evaluating timelines, costs, and best options for remediation.

Based on the remediation action plan developed in Phase III, actions can be taken to remediate the contaminated land. After that, a second-round of Phase II assessment can be performed to confirm the contaminated land has been fully remediated. Due to the environmental impacts of coal ash, coal ash storage facilities are considered as potentially contaminated sites even if the stored coal ash has been completely removed for beneficial uses. Therefore, to turn coal ash storage facilities to sites for constructing public infrastructure projects, the facilities need to go through a Phase II assessment. If the facilities are determined to be contaminated lands during the assessment, Phase III assessment must be conducted to develop a remediation action plan. Only when the environmental contaminants are fully remediated can the facilities be considered suitable, from the environmental aspect, for use as sites for constructing public infrastructure. It is recommended that the assessment and remediation work be completed by environmental companies with professional environmental assessors and chemists. Figure 21 shows a recommended procedure for qualifying coal ash storage sites for public infrastructure from the environmental aspect.

Once coal ash storage sites are qualified from the environmental aspect, several other evaluations need to be carried out, such as landscape, size, shape, and topography, utilities and raw materials access, road and transportation access, and zoning and regulations. These evaluations should be conducted by professional construction and/or consulting companies.

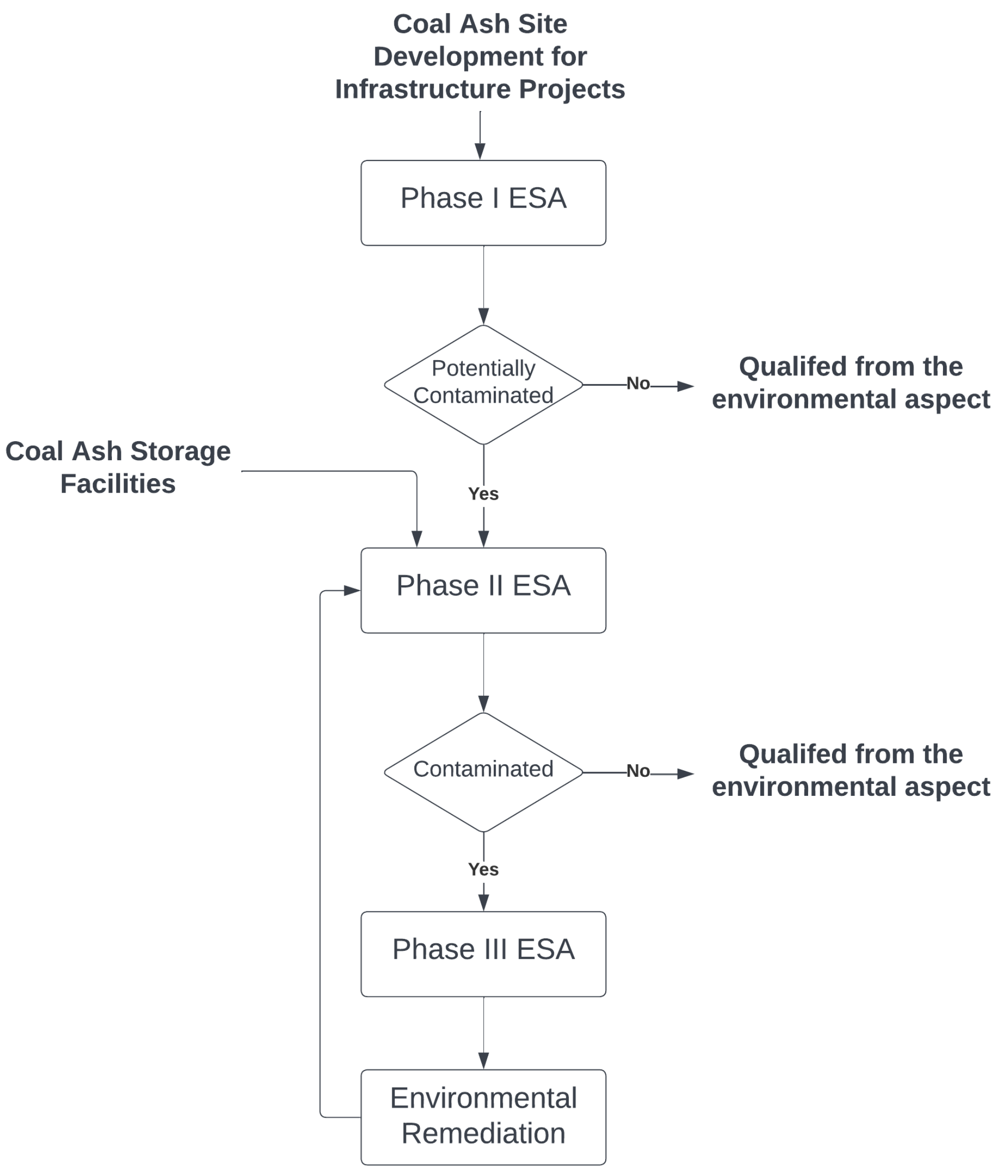


Figure 21: A recommended procedure for qualifying coal ash storage sites for public infrastructure from the environmental aspect

3 CROSSOVER ASPECTS

Part 3 of this report is intended to merge information and processes that are reasonably common to both of the waste products addressed in this report: gob piles and coal ash landfills. This approach was chosen to avoid duplications and redundancies; however, where appropriate, specific comments pertaining to only gob piles or coal ash storage are also included for completeness.

3.1 Characterization of Gob Piles and CCR Storage Facilities

Characterization of stored waste streams is a major program, performed in stages that include site visits and verification, in-situ exploration and sampling, laboratory and field testing, assessment of health and safety conditions and risks and potential environmental concerns. Characterization will also identify type and quality of resources that can be produced as value-added downstream product(s). Off take considerations and potential market must also be considered. Additional considerations are material and surface ownership, permissions from the agencies involved and communication with the local community. Workforce plans, including training or re-skilling needs, should also be considered at this stage. The design and execution of the operation and the necessary assessment of capital expenditure and operating costs will heavily rely on the success of this program to define the final commercial viability of a project.

3.1.1 Exploration and Evaluation

In practice, **Preliminary Exploration** will include visit(s), verification via surveys and aerial images, in-situ mapping, shallow sampling, limited laboratory or in-situ testing, health and safety conditions and environmental issues and will provide a guide to developing site logistics for going forward. In parallel, historic coal mining activity that can identify specific coal seams contributing to the gob pile should be investigated, as well as ownership of the minerals specifically contributing to the coal waste piles. This is a comparatively low cost and low work-effort commitment that would lead to a GO or NO-GO decision for the next stage.

A positive preliminary assessment is then followed by a **Project Evaluation** stage that includes rigorous investigation of the stored waste, geophysical and geochemical profiles, systematic drilling into the subsurface, with core recovery and testing at varying depths and at tight spacing, in order to evaluate the entire three-dimensional profile of the waste material. In-situ tests to determine compaction, size distribution and stability of slopes should also be included and any potential hydrological concerns. Development of an “ore model” will be useful, because at this stage the waste is basically treated as an ore body containing valuable resources. Resources can be estimated using acceptable standards recognized by the financial community and the standards promulgated by the United States Securities and Exchange Commission (SEC)- *Modernization of Property* Disclosures *for Mining Registrants (Regulation S-K, Subpart 1300* - commonly referred to as the S-K1300 standards). Other global standards of interest and standardization committees include ISO 22450:2020(en)-Recycling of rare earth elements, the ISO Technical committee on Rare earth Standardization (ISO/TC 298); the JORC

Code (https://www.jorc.org/) and CRIRSCO (Committee for Mineral Reserves International Reporting Standards, https://www.crirsco.com/)

By comparison to the previous Exploration stage, Evaluation is costly, systematic and requires time and significant effort. It provides, however, a complete project design report with financial information (similar to a Front End Engineering Design, FEED). This is a “bankable” document, acceptable for approaching financial institutions. The Performance Protocol described later in this section will provide a more step by step process for developing a specific project.

3.1.2 Sampling

Sampling protocols should be guided by the initial investigation of the individual sites, which will help create a unified approach to resource characterization. In addition, for larger storage facilities, before exploration and sampling, it is recommended that geophysical and/or geochemical surveys be performed for an initial assessment. This information can map potential karst features and identify probable groundwater seepage through and beneath gob piles and ash landfills. In addition, geochemical survey can analyze potential concentration of toxic elements present at the waste material and also provide a base line for the proximate area.

Generally, sampling approaches with coal waste piles will involve hand sampling, trench sampling or drilling and coring for samples for more detailed analysis. The size and complexity of the coal waste pile site will influence the type of sampling method. Smaller coal waste piles can usually be adequately characterized by hand or trench sampling. Larger coal waste piles may require extensive drilling and coring to adequately sample and characterize multiple zones of varying concentrations of materials placed on extended time periods. The sampling plan needs to be designed in concert with the intended utilization of the feedstock materials and the anticipated processing methodology.

Larger complex fly ash landfills will most likely involve drilling and coring for samples. The first step in successfully characterizing a fly ash landfill/impoundment is to collect as much information about the landfill/impoundment as possible from the power utility. Important information includes the start and end dates of the landfilling/impounding operations, changes in the power production process, source of coal, or coal rank during the landfilling/impounding period, any co-mingling of fly ash and other materials, and the pattern in which the landfill/impoundment was filled and stratified. When reliable information is obtained, advancing with the exploration plan of Method A is recommended; otherwise, Method B is suggested to identify and follow the heterogeneities within the landfill/impoundment and to determine the separation necessary. The details associated with each of these approaches are outlined in Appendix 12 Standardized Sampling and Testing Methods for Gob Piles and Coal Ash Storage Units.

Protocols common to each of the sampling methodologies, plus more extensive details, have been outlined in Appendix 12. All sampling activity should be conducted under the supervision of a qualified person to ensure adherence to approved and recognized best practices.

3.1.3 Testing

Testing parameters will also be dictated by the initial characterization and the anticipated utilization. Standardization of individual test parameters along with accepted laboratory methods must be developed to define potential resources. A database of the laboratory assay results should be created and maintained to facilitate developing models that can aid in the future decision-making process among sites where commonalities are readily evident. Testing data will help to develop a hierarchy of co-products that will direct processing activities along with economic viability.

Laboratory testing parameters and methods related to the anticipated utilization streams of the coal waste and fly ash materials are well documented within the research and industry communities and do not need to be restated. Coal waste materials identified for thermal electricity generation will require specific analyses that generally track coal resources. High value carbon products and Critical Mineral (CM) and Rare Earth Element (REE) characterization will require extensive laboratory testing on an elemental basis to adequately identify the most promising materials concentrations that will drive implementation of processing technologies. Fly ash material targeted for use within the construction sector will have additional specific testing requirements. In addition to the testing requirements needed to define utilization streams there will be additional tests required to identify any potential environmental concerns. A detailed description of the initial and quality control explorations for coal ash landfills developed by Kaladharan et al. (2019) is presented in Appendix 12, Quality Control Exploration.

During material handling, identifying constituents that may generate toxic runoff or result in adverse impacts to surrounding surface and groundwater systems will be an important consideration. Geotechnical testing to ensure compaction and stability, and analysis of any potential slope instability are routinely performed to ensure the structural integrity of the storage facility. In most cases, sensing and monitoring can provide remote and continuous observation that can inform any potential remedial actions.

3.1.4 Characterization and Prioritization

As mentioned before, characterization and subsequent prioritization for renewal of a gob pile or coal ash waste is a complex exercise and goes far beyond the simple screening process explained in section 1.2.3 Gob Pile Screening Versus Characterization. Decisions in this case must be based on technical, environmental, social and market considerations for downstream chains and products. Financial and commercial exposure and concerns are also extremely important in prioritizing projects. With the exception of AML gob piles, where the federal government can provide some financial assistance and only for the remediation process, in all other cases coal waste renewal necessitates a healthy and financially independent private venture. These influences of determining characterization, viability and prioritization are depicted in Figure 22.

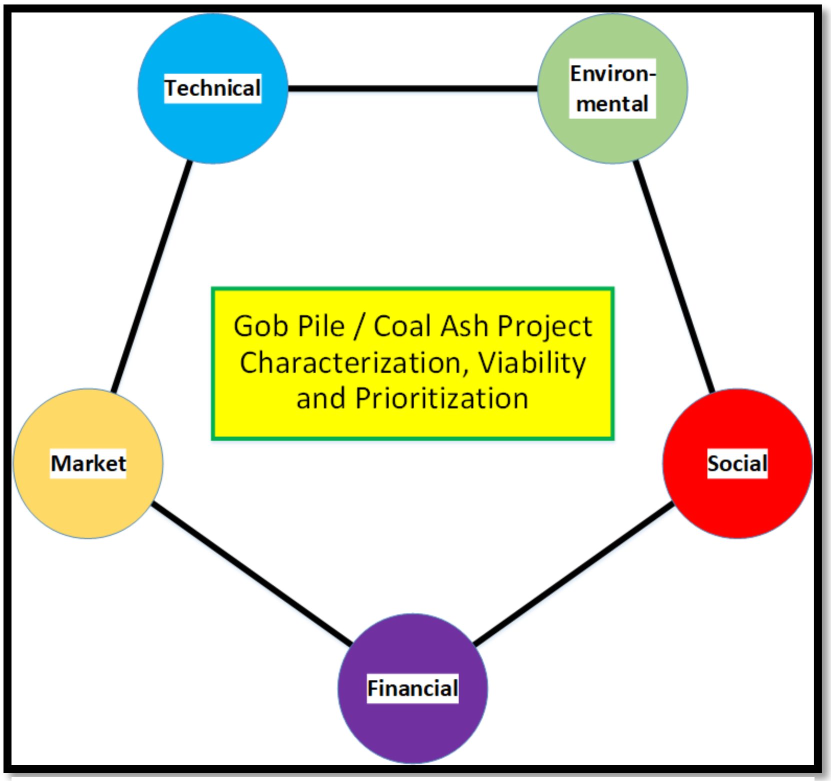


Figure 22: Parameters Impacting Gob Pile Characterization, Viability and Prioritization

The development of a complex characterization metric system, with appropriate rankings and weights, must be devised that can assist in the development of a comprehensive and well-informed gob pile priority assessment and renewal schedule.

3.2 Developing a Performance Protocol for Gob Piles and Coal Ash Renewal

Many of the steps involved in assessing and developing protocols for renewal performance for gob piles and coal ash waste storage facilities require similar steps and follow a comparable path and sequence. To avoid duplication and redundancies, the Karmis LLC (2022) Coal Waste Streams Report recommends a common pathway, in 3.2.4, for stored waste material, recognizing that some steps may be applied differently depending on the case, i.e., gob coal or coal ash material.

3.2.1 Environmental Justice Considerations

Environmental justice is defined as the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, income, faith or disability, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Environmental justice is achieved by everyone when the same degree of protection from environmental and health hazards and equal access to the decision-making process result in a healthy environment in which to live, learn, and work.

Screening tools such as EPA's EJScreen (https://ejscreen.epa.gov/mapper/) and the US Department of Energy's Energy Justice 40 (https://energyjustice.egs.anl.gov/) can be used for a "screening-level" evaluation of a particular project, using location (i.e., county) stress level, based on generally accepted and established criteria. Screening results should always be supplemented with additional information and local knowledge to reach a better understanding of the issues in a selected location.

The Department of Energy (DOE) Energy Justice 40 tool is intended to allow users to explore and produce reports on census tracts that the DOE has categorized as disadvantaged communities (DACs), pursuant to Executive Order (EO) 14008 - Tackling the Climate Crisis at Home and Abroad. Section 223 of the EO established a goal that 40% of the overall benefits of certain federal investments flow to DACs. Most Southwest Virginia coal counties, where gob piles are located, are identified with a DAC Status of disadvantaged.

Virginia legislation established the Virginia Council on Environmental Justice "to advise the Governor and provide recommendations that maintain a foundation of environmental justice principles intended to protect vulnerable communities from disproportionate impacts of pollution." The Virginia Environmental Justice Act (Senate Bill 406/House Bill 704) mandated that "the policy to promote environmental justice… is carried out throughout the Commonwealth."

Renewal of gob piles and CCR storage facilities will improve the local and regional environment by eliminating a potential environmental liability through beneficial use of the waste material. Using advanced technologies and practices, waste renewal will aim to advance beyond recycling towards circular economy goals. In addition, developers of gob piles and CCRs will be required to ensure fair treatment and involvement of its customers and neighbors and the communities impacted should have ready access to accurate information regarding the project development process.

Developing products and new raw materials from gob piles will allow the development of new clean industries that can be established locally, for easy access to source material. These new industries, to a great extent, involve clean, high technology manufacturing. The material of higher thermal value (e.g., 1,000-6,000 BTU) can be blended and used to supply material to the Virginia City Hybrid Energy Center (VCHEC), which was specially designed to use waste coal and biomass and will ensure that this clean power plant can continue to operate in the region.

Beneficial use of CCRs will produce concrete, concrete products or traditional cement replacements, which are fundamental construction materials. The local and global environment will improve since the recycled ash in concrete will reduce the embedded carbon associated with the traditional concrete manufactured in the regional markets in eastern Virginia. The greenhouse gas (CO_2) avoided through replacement can also be a valuable Carbon Credit.

3.2.2 Excavating and Harvesting Gob Piles and Coal Ash Storage Facilities

The primary considerations when extracting material from gob piles and/or coal ash storage facilities are personnel safety and environmental protection. Thus, material extraction should be performed by taking all necessary measures to ensure that there is an adequate safety factor built in all geotechnical aspects (e.g., material stability) of the extraction sequence. At the same time emphasis should be given to eliminating risks and minimizing environmental impacts that may arise due to excavation practices, such as impacts to surface waters and/or the groundwater horizons in the vicinity of each project. Thus, the overall design or designs should not only meet available standards for responsible extraction, including best practices available for similar projects, but should go above and beyond such standards to ensure sustainable and responsible extraction practices.

3.2.2.1 Issues and Actions for Renewal of Coal Gob Piles

A high degree of variability often exists in gob pile materials within the same disposal area, since individual prep plants often process several coal seams (Stewart, 1990; Stewart & Daniels, 1992). Each seam may exhibit different mineralogical, chemical, and physical properties. This variability makes the development of strategies for downstream processing technologies difficult. Additional variability is introduced through weathering of the placed refuse materials over time.

Recent gob piles are engineered to maximize volume capacity while minimizing "footprint," or land area occupied. Minimizing acreage necessitates the construction of steeply sloping embankments, which tend to be heavily compacted in order to maintain surface stability. Steep slopes can complicate environmental renewal efforts in several ways from extraction to final reclamation success, may generate seeps and springs, and cause difficulties in maintaining overall slope stability.

Many older gob piles are high in coal fragments; often, such piles were constructed in loose, unconsolidated configurations which may allow oxygen to interact easily with the refuse. Because pyrite oxidation is an exothermic (heat producing) reaction, inspections for spontaneous combustion possibilities are warranted, although they are rare due to improved design practices that limit aeration. When they do occur, they are generally the result of accidental ignition.

Below, a number of detailed considerations and actions are discussed in more detail.

Excavation Considerations

The recommended excavation approach should be a Top-Down sequence as this approach mitigates risks associated with failure of slope structure and limits the extent of disturbance. In addition, the following will ensure safe extraction:

a) Excavation should be essentially level and will remove all material allowing exposure of the original ground before proceeding to lower elevation.
b) Excavation depths should not exceed intervals of 10 feet in thickness.
c) The exposed original ground should be graded and seeded to minimize erosion.
d) A ditch should be established and maintained along the gob/original ground interface and should drain towards sediment control structures.
e) After each cut slope stability should be maintained in case of unexpected (short term or long term) stops while working on this project.

Credible failure modes reported should be reviewed. Emphasis should be on those rooted in the presence of water that can exacerbate the consequences of a potential failure, even *if water is not the initial failure trigger*. The following practices decrease the probability of failure:

a) The final slopes should not be steeper than 2:1.
b) Safety benches should be constructed every 50 vertical feet.
c) Safety benches should be at least 20 feet wide and sloped 5% away from the final outslope.
d) Safety benches should be sloped at least 2% to groin ditches.
e) Lift thickness should be based upon the material placed and should never be greater than two vertical feet.
f) Material should be compacted to at least 90% of maximum dry density based upon the standard proctor and within ±2% of the optimum moisture content.
g) Compaction testing and moisture content should be conducted at least one time per 2,000 cubic yards of material placed or one test for every lift placed, whichever is greater (MSHA 2010). It should be noted that any soil placed as part of a structural fill, including coal refuse in embankments, is normally compacted to increase density and shear strength and to decrease compressibility and hydraulic conductivity. This makes relatively steep slopes possible, reduces seepage from impoundments, and reduces the potential for spontaneous combustion by reducing the flow of air and water into the embankment (MSHA 2010).
h) Manage water by providing diversion of surface water whereby clean water diversions should be constructed above refuse facilities to convey drainage around the facilities during refuse recovery operations.

A sufficient haul route to access the gob pile should be established. The following practices will ensure safe operations:

a) The main access/haul routes should be constructed off the gob pile and on adjacent surface to minimize disturbance of the gob pile.
b) Access to the active excavation area within the gob pile should be via a level or near level road segment branching from the main access/haul route.
c) A slight rise in the road segment at the gob pile interface should be maintained to prevent water and material from flowing off active excavation area.

The disturbed area should be minimized. The following practices will ensure safe operations:

a) If the gob area is in excess of 10 acres, it can be considered for possible division into discrete sections and disturbance and associated excavation can take place on an individual basis, providing that it does not impact the stability of the remaining areas. Gob areas smaller than this areal extent should be developed as a whole.
b) "Outslope" surfaces will only be disturbed incrementally associated with excavation.

Engineering controls should be established to mitigate geotechnical and geochemical risks if water enters the site. Drainage structures should be checked monthly and after rainfall events to ensure structures are still functioning properly.

It is considered best practice for gob pile stability to start reclamation operations while mining a gob pile. This coordination will utilize existing equipment and be built into the mining cost. This is also the preferred practice by many surface mining operations and will contribute to enhancing stability of the slopes. However, if the specific site conditions do not allow conducting reclamation operations in parallel with gob mining, then reclamation should occur as soon as possible after mining has been completed.

Best practices from other related Industries (e.g., ICMM, 2021b; USEPA 2001) can provide additional resources.

Environmental Considerations

The possibility of Acid Mine Drainage (AMD) increase should be assessed. Significant excavation of existing stable refuse piles has the potential to expose deeper relatively non-weathered materials to a more oxidizing and water-rich environment, so at least a short-term increase in AMD production should be expected and can be managed via containment and/or treatment.

The current environmental conditions must be assessed using a stringent monitoring program that also establishes baseline data for future measurements. In particular, the following should be collected:

a) Baseline surface water quality data – monthly instream samples (6 months minimum),

b) Baseline groundwater quality data – monthly underdrain samples (6 months minimum),
c) Baseline biological monitoring data –samples in the fall and spring sampling periods,
d) Signs of active or historic combustion.

The drainage conditions prior to and during renewal of a waste facility must be established. Particular emphasis should be directed to:

a) Adequacy of existing drainage structures, i.e., significant erosion.
b) Size of permanent drainage structures so that they can pass the peak discharge from a 100-year, 6-hour storm event.
c) Size of temporary drainage structures so that they can pass the peak discharge from a 10-year, 6-hour storm event.
d) Certifications to monitor stability and sediment capacity on an annual basis.
e) Fill certifications to monitor stability and operational status on a quarterly basis.
f) Anniversary reports to truck-disturbed, regraded and vegetated areas on an annual basis.

The presence of any toxic material or releases should be assessed. Such occurrences may require safe permanent storage and should be identified by conducting acid base accounting, including total sulfur and pyritic sulfur quantification, on samples collected during exploration operations to determine the potential for toxic material.

The current ground hydrologic conditions should be assessed. This is important to better evaluate waste structure water inflows and outflows, including expected variations over time. Groundwater quality data must be collected on a monthly basis (underdrain samples).

A water management plan must be developed. Efficient measures should be evaluated to minimize the water that can potentially permeate the structure. This includes:

a) The construction of clean water diversions above refuse facilities to convey drainage around the facilities during refuse recovery operations.
b) Drainage of slope benches and fill crests to stabilized channels with a minimum slope of 2%.
c) The establishment of vegetation in contemporaneous manner after final regrading operations.
d) The capping and covering of completed refuse disposal areas.

Design Considerations

Current, intermediate and final stability analyses should be performed. The final stability analysis should be based on an as-built survey and submitted with final as-built certification.

In-situ testing must be performed to preserve structural integrity. This includes compaction testing and moisture content that should be conducted at least one time per 2,000 cubic yards of material placed or one test for every lift placed, whichever is greater (MSHA, 2010).

Continuous stability monitoring should be performed during the renewal process. Such a program may provide additional information and potential actions for ensuring structural gob pile integrity.

The site should also be evaluated with respect to post-operations land uses. Appropriate remediation actions may need to be implemented to facilitate post-operations land development for productive and community acceptable use.

3.2.2.2 Issues and Actions for Renewal of Coal Ash Landfills

As part of the excavation sequence, a water management plan should be developed since water removed will require handling in compliance with both surface water regulations and contact water treatment or management requirements.

Once the excavation begins, a continuous monitoring program should be designed to ensure that changes in the surface and/or subsurface conditions are detected. Testing of the materials removed should continue to ensure that the assumptions about the material character used in the slope stability evaluations remain accurate for the actual materials encountered. Variability between subsurface boring locations can cause assumptions to be invalid and material monitoring during the actual removal process can verify assumptions and stability modeling or highlight areas of concern requiring re-evaluation.

Excavation Considerations

A properly designed excavation plan should be developed. One of the key considerations is safety when harvesting CCRs from any storage unit where moisture intrusion can cause subsurface layers of the stored materials to have elevated pore pressure or planes with preferential slip surfaces during to material deposition. To remove materials safely, a properly designed excavation plan must be developed based on a subsurface geotechnical evaluation.

A subsurface evaluation should be conducted. The subsurface evaluation should identify water levels and existing pore pressures at various elevations. With known subsurface conditions the requirements and design for dewatering systems can proceed. Water removal, pore pressure management, and slope stability should be evaluated for various potential excavation plans in order to select the proper removal approach.

The recommended excavation approach should be a top-down sequence as this approach mitigates risks associated with failure of slope structure and limit extent of disturbance. In addition, the following should be taken into consideration to ensure safe extraction:

Excavation should be essentially level and will remove all material allowing exposure of the original ground before proceeding to lower elevations. In particular:

a) Excavation depths (lifts) should be limited based on geotechnical considerations.
b) The exposed original ground should be graded and seeded to minimize erosion.

c) A ditch should be established and maintained along the CCR/original ground interface and should drain towards sediment control structures. As operations may be paused in the short or long term, it is critical that materials should be extracted in lifts ensuring stability of the remaining material.
d) Potential failure modes reported should be reviewed with emphasis on those triggered due to the presence of water.

A continuous monitoring geotechnical program should be established. Once the excavation begins, a continuous monitoring program should be designed to ensure that changes in the surface and/or subsurface conditions are detected. Testing of the materials removed should continue to ensure that the assumptions on the material character used in the slope stability evaluations remain accurate for the actual materials encountered. Variability between subsurface boring locations can cause assumptions to be invalid and material monitoring during the actual removal process can verify assumptions and stability modeling or highlight areas of concern requiring re-evaluation.

Engineering controls should be established to mitigate geotechnical and geochemical risks if water enters the site. Drainage structures should be checked monthly and after rainfall events to ensure structures are still functioning properly.

Environmental Considerations

Coal ash properties should be monitored. The physical and chemical properties of coal ash should be monitored before and during harvesting or excavation. In addition, groundwater monitoring associated with coal ash placement should be conducted before and during harvesting or excavation. A baseline should be established for surface water quality, groundwater quality data, and biological processes. Upgradient and downgradient monitoring wells may need to be established.

The potential presence of toxic materials should be established. The presence of any toxic material or releases that may require safe permanent storage should be identified by conducting appropriate tests for heavy metals and other toxic elements that may be present in a specific storage area. Potential leakage of effluents to groundwater horizons should also be evaluated before and during harvesting operations. A management plan should be in place to isolate and safely dispose of such effluents.

A water management plan should be established. As part of the excavation plan, a water management plan should also be developed since water removed will require handling in compliance with both surface water regulations and contact water treatment or management requirements.

Site drainage conditions should be established. The drainage conditions prior to and during harvesting of a CCR facility need to be established with particular emphasis on large scale storm events that may lead to excessive drainage loads on existing infrastructure. Effective drainage should be maintained at all times.

Dust control should be established. Both the harvesting and transportation of the material should be performed under a dust control plan to avoid fugitive dust emissions.

Design Considerations

Coal ash should be appropriately classified in terms of geotechnical properties. For purposes of engineering, uniformly placed coal ash can be considered as an artificial "soil" type that is usually more uniform than a natural soil layer. In general, coal ashes can be classified into coal source types (bituminous or anthracite), coal ash source (segregated or unsegregated fly and bottom ash), coal ash "gradation" (classification based upon the sizes of the ash particles). The coal ash classification is normally that of silt loam. In coal ash landfills at both conventional ash disposal sites and demonstration ash sites, standard tests are run, and data is gathered. From this, an estimate of the ash's strength or bearing capacity can be made. The coal ash strength and bearing capacity sets the upper limit on potential building types, and other future uses.

Appropriate geotechnical samples should be collected. In-situ testing using cone penetrometer (ASTM D5778) and dilatometer (ASTM D6635) equipment is routinely used for geotechnical characterization of coal ash facilities. Shear wave velocities obtained by in-situ measurements are also valuable to geotechnical design. Samples for geotechnical testing should be collected from boreholes for general index testing and hydraulic conductivity (i.e., permeability) testing. Samples should be from random depths based on field conditions, for general index testing. The number of samples depends on the size of the site that is evaluated. Index testing would include the following:

a) Grain size distribution (ASTM D6913 and D7928),
b) Specific gravity (ASTM D854 or C311),
c) Moisture content (ASTM D2216 or C311),
d) Atterberg limits (ASTM D4318),
e) Hydraulic conductivity testing (ASTM D2434),
f) Triaxial C-U tests (ASTM D4767), and
g) Particle morphology by scanning electron microscope (no ASTM).

Geotechnical samples may also be useful in evaluating potential beneficial use of coal ash. A list of tests for beneficial use is included in Appendix 9 Table 9.

Geotechnical testing should be conducted. Each of these types of tests may be conducted on undisturbed Shelby tube samples or on recompacted material, depending on the condition of the samples collected. Disturbed samples selected for C-U testing will also include modified Proctor tests (ASTM D1557) to match the compaction required by the coal ash landfill specifications.

The site should also be evaluated with respect to post-operations land uses. Appropriate remediation actions may need to be implemented to facilitate post-operations land development, for productive and community acceptable use, including conversion to potential sites for constructing public buildings and facilities.

3.2.3 A Pathway to Renewal of Gob Piles and Ash Landfills

Standards and Best Engineering Practices (BEP) are important for establishing clear expectations of safe and responsible performance. These are also emphasized in the scope of the Karmis assignment. With this in mind and compiling the information from previous sections of the report, a broad roadmap has been developed to effectively guide the renewal process, which includes coal gob piles and ash landfills storage facilities. The approach followed below is to implement broad, generic, pathways with benchmarks and practices that include **Phases**, **Steps** and overarching **Platforms**. It is appreciated and accepted that not all potential aspects that may be encountered in practice are necessarily included, and some listed may not apply to a particular case under investigation; however, the overall guidance recommended can provide direction and adherence to acceptable standards of performance and can also demonstrate that responsible practices are followed for the renewal lifecycle of a storage facility.

Phase 1. CHARACTERIZATION AND ANALYSIS

- **Step 1: Identify and Explore**
  a) Location, conditions, ownership and access
  b) Evaluate footprint, volume and potential source material
  c) Obtain all applicable state and federal approvals

- **Step 2: Characterizing and Testing**
  a) Develop sample frequency and methods for exploratory testing based on appropriate BEPS
  b) Plan for systematic testing of the waste material to develop a complete profile, using a 3-d grid coring program adhering to BEPS
  c) Develop a resource assessment of material(s) of interest for downstream utilization using acceptable BEPS

Phase 2. ENVIRONMENTAL CONSIDERATIONS

- **Step 3: Environmental Assessment**
  a) Assess current and future environmental conditions and challenges
  b) Evaluate drainage conditions prior to and during renewal of a waste facility
  c) Identify presence of any toxic material or releases that may require safe permanent storage

- **Step 4 Hydrologic Assessment**
  a) Evaluate ground hydrologic conditions in order to better evaluate waste structure water inflows and outflows, including expected variations over time
  b) Develop a water management plan and evaluate efficient measures to minimize the water that can potentially permeate the structure
  c) Observe best practices from other related industries (ICMM, 2021b)
  d) Review credible failure modes reported, especially those rooted in water management and the presence of water that can exacerbate the consequences of a potential failure, even if water is not the initial failure trigger.
  e) Manage water, by providing diversion of surface water
  f) Establish engineering controls to mitigate geotechnical and geochemical risks if water enters the site

Phase 3. DESIGN CONSIDERATIONS

- **Step 5: Assess Current Structural Stability and Future Renewal Implications**
  a) Perform current, intermediate and final stability analyses
  b) Identify and conduct any in-situ testing that must be performed to facility structural integrity assessment
  c) Organize a program of continued stability monitoring during the renewal process, using remotely accessible sensors

- **Step 6: Geotechnical Evaluation of the Waste Structure Through the Entire Life-Cycle of the Renewal Process**
  a) Perform geotechnical evaluation and analytical testing, to determine water levels and pore water pressures during site excavations
  b) Consider geotechnical steps for preparation, staging excavation and segregating or stockpiling separate materials
  c) Organize a program of continued geotechnical monitoring and assessment during the renewal process, using remotely accessible sensors

Phase 4. SEPARATION AND PROCESSING

- **Step 7: Develop a Materials Sorting Program**
  a) Identify BEP and equipment necessary to prepare material for downstream utilization
  b) Plan for disposing or storing remnant material for end-of-life reclamation of the site
  c) Develop a plan for safe disposal/storage of any toxic constituents

- **Step 8: Material Separation for Beneficial Use**

a) Select the appropriate separation technology for isolating waste streams that have a beneficial use
b) Identify equipment necessary to produce concentrates of the valuable resources
c) Develop a stockpile plan for the beneficial stream(s) and for any waste residues that are created during the separation process. Use Step 4 as a guide for aggregating waste materials on-site or off-site

Phase 5. RECLAMATION AND POST MINING LAND USE

- **Step 9: Site Reclamation Upon Completion**
  a) Develop a post-operations acceptable reclamation or alternative land use plan
  b) To the extent possible, use source material(s) created during the renewal of the waste pile
  c) Emphasis should be placed on novel reclamation practices that could act as sinks for greenhouse gases

3.2.4 Overarching Platforms

- **Platform A: Assure that All Pertinent Approvals and/or Permitting Requirements are Obtained**
  a) Obtain all necessary permits and agreements from all owners potentially impacted by waste renewal and utilization development, including surface owners, mineral owners and waste owners
  b) Use BEPS, to develop permitting information required by the state and federal agencies that have regulatory oversight of some, or all, of the steps outlined above

- **Platform B: Risk Management**
  a) Identify technical, environmental, health and safety, financial, social and management risks
  b) Assess the potential of identified risks and perform a risk analysis
  c) Develop risk mitigations and risk management plans
  d) Plan for an open-ended, continuous risk assessment process, risk review, risk communication and risk plan update

- **Platform C: Community Support and Engagement and Environmental Justice Principles and Practices**
  a) Proactive engagement of the waste developer with key stakeholders is critical and should form the basis for discussions on sustainable development and responsible practices, challenges and opportunities, in an open and transparent manner
  b) Adhere to environmental justice principles and equal access to the decision-making process to have a healthy environment

c) Use the accepted screening tools developed by EPA, EJScreen (https://ejscreen.epa.gov/mapper/) and US DO's Justice 40 (https://energyjustice.egs.anl.gov/) for a "screening-level" evaluation of a particular waste site using location (i.e., county) stress level, and based on well accepted and established criteria.

- **Platform D: Prioritize Waste Facilities for Future Renewal and Access to Potential Funding**
  a) Develop a ranking system to establish a sequence that prioritizes facilities eligible for renewal, using and combining criteria from all phases
  b) Assess renewal urgency based on environmental and health and safety considerations
  c) Consider Platforms A, B and C in the ranking system
  d) Identify opportunities where federal or state funds are available for renewal projects
  e) Identify incentives challenges and barriers for financing commercial gob pile projects
  f) Encourage incentivized investors to engage in commercially viable projects involving renewal of waste facilities

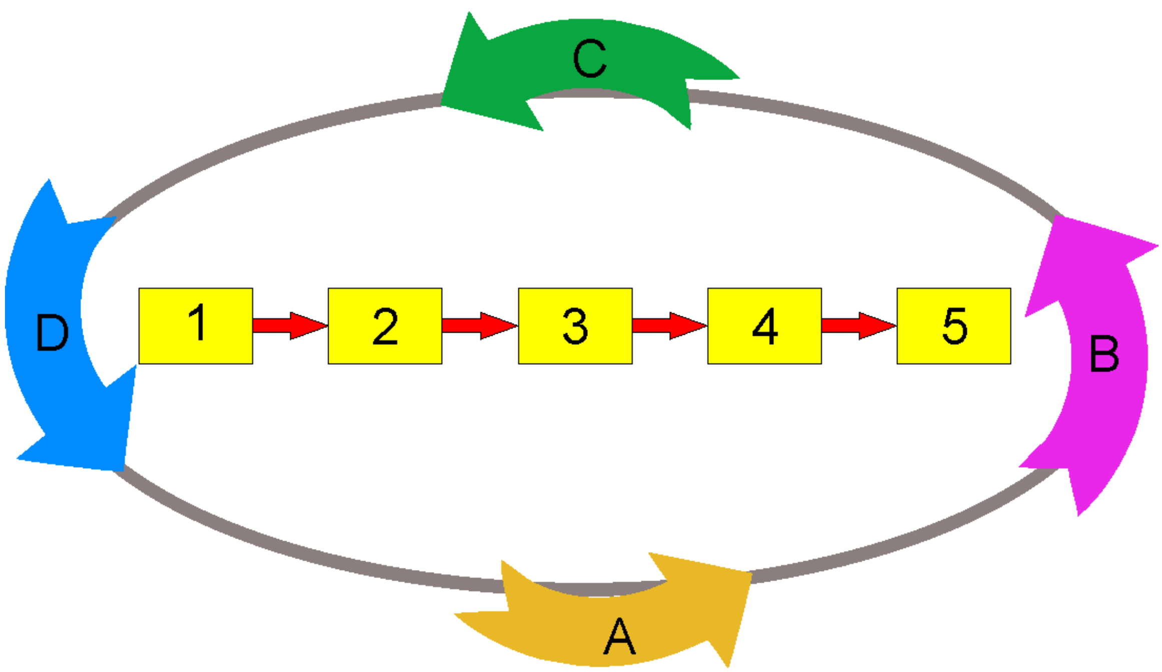


Figure 23: Performance Protocol- Phases 1-5 and Platforms A-D

4 A ROADMAP TO THE FUTURE: PATHWAYS, INCENTIVES, AND CHALLENGES

Based on the discussion and findings of the Karmis LLC (2022) Coal Waste Streams Report, the Author presents below a Roadmap for future action by the Commonwealth of Virginia that includes priority pathways to be pursued, incentives needed to promote coal and ash waste stream renewal and administrative challenges that should be overcome.

4.1 Priority Pathways

1. **Virginia Energy should continue and expand the current effort to create a master plan for the renewal of gob piles in Southwest Virginia.** The master plan will serve as a platform allowing for multi-parameter characterization and prioritization, using the criteria discussed in this report, leading to the development of a hierarchy of qualified projects for renewal.

2. **Virginia Energy should direct resources to urgently launch a comprehensive gob pile characterization effort that can lead to coal gob recovery and potential downstream processing.** This will enable a comprehensive program of sampling, testing and analysis of gob piles, forming the foundation of the above master plan and providing the necessary metrics for assessing and evaluating renewal opportunities. In addition, this data base will encourage and accelerate commercial deployment of the coal waste streams that can be coupled with incentives to locate downstream industries in the area. The AML funding can be one source of stimulus to accomplish this goal for qualified site-specific or regional remediation efforts.

3. **Virginia Energy should support pilot demo projects that can demonstrate new technologies to scale.** Virginia Energy can provide assistance to facilitate a framework for pilot projects hosted in Southwest Virginia, involving new technologies that must demonstrate their applicability to scale. This can also be facilitated by the recently announced DELTA Lab located in Southwest Virginia (https://www.energydeltalab.org/).

4. **Virginia Energy should promote diffusion of innovation and share best practices and methodologies with key stakeholders.** This report provides direction and components for pursuing this path for Southwest Virginia and for expanding cooperation and coordination avenues with the neighboring, Central Appalachian State agencies and other initiatives focused on Gob piles renewal.

5. **Virginia can be elevated to a unique position in the nation, by establishing the Commonwealth as a hub for the production of critical minerals, including REE, and carbon products.** Systematic production from waste streams, the scope of this report, can be augmented with additional opportunities for the exploitation of other such mineral occurrences that have been identified throughout the state.

4.2 Meaningful Incentives

6. **Virginia must commit additional resources, including personnel, if the Commonwealth is to advance its position as the leading state in gob pile and coal ash renewal and beneficial use.** Moving aggressively to accomplish this objective will require commitment from the state to significantly increase current state agency capacity and capability.

7. **Virginia must consider private-sector incentives for gob pile renewal and downstream value-added supply chains.** Much of the renewal effort will be left to the private sector. Given the risks and uncertainties, particularly with new technologies and volatile markets, an incentive program will be necessary to stimulate this new industry. Tax credits and/or other incentive tools should be seriously considered.

8. **Virginia must develop incentives, and remove deterrents, for re-opening closed CCR units.** If a facility unit has already been closed, under a federal or state regulatory program, there is not currently any incentive to re-open that unit, unless there is a compelling reason to disturb a closed facility. Such incentives are essential if valuable resources, including construction materials, critical minerals and other potential marketable byproducts, contained in the CCR material are to be explored and storage sites are to be transformed and considered for potential construction projects.

4.3 Moderate Challenges

9. **Virginia Energy and other related state agencies, including Virginia DEQ and DOT, should be encouraged to aggressively pursue federal funding available via major federal solicitations and programs.** Funding available through the Bipartisan Infrastructure Bill and the Inflation Reduction Act provide unique funding opportunities that can be cost shared by state resources. In addition, many of these solicitations are especially aimed at disadvantaged communities (DACS), such as those of Southwest Virginia and other rural regions in the state. These federal funding opportunities are highly competitive and are often awarded to large public-private partnerships. Agencies such as Virginia Energy can play a leading role in such collaborations, but they will require additional research capacity in conjunction with some cultural changes.

10. **Virginia must support opportunities for job creation generated by the production of new materials for downstream applications and supply chains, which can transition employment opportunities in Southwest Virginia.** Traditional employment positions, retraining a workforce for new opportunities and even developing a high-tech workforce for the new materials supply chain, will require essential changes to the workforce demographics. The Commonwealth must provide incentives not only for retraining workers, but also for significantly expanding and diversifying employment opportunities and careers. Such an effort should also include STEM education paths for attracting and preparing the Z-generation workforce in the coalfield and rural regions.

11. **Virginia must promote regulatory alignment.** Removal of legacy deposits of CCRs or gob piles from impoundments or landfills requires federal and state compliance. Regulatory alignment is necessary to develop the complex geotechnical, processing and civil engineering projects required for beneficial use.

12. **Virginia can create a pathway for promptly resolving CCR impoundments and landfills confronted with additional regulatory schemes or legal actions.** In addition to federal and state compliance, owners are confronted by ongoing court cases and rulings which redirect EPA or states to review and modify the applicable regulatory pathways. This in turn, can impact closure, closure timelines and final disposition of the CCRs and facility units.

13. **Virginia can provide clarity to utility and industrial owners of CCR management facilities.** These owners desire clarity on all regulatory fronts and, in the case of utilities, there is a need to clarify cost recovery through the regulated electricity markets. Clarity is also needed for responding to potential development opportunities on fly ash storage sites by defining "public infrastructure projects" and their potential ownership. In addition, the differences, if any, between public infrastructure at closure-in-place sites versus those at closure-by-removal sites, should be addressed.

14. **Virginia must promote ultimate pathways when beneficial use is mandated.** Utilities must decide how their CCRs can be utilized when beneficial use is mandated. The actual use selected always carries certain potentially responsible party (PRP) liabilities. Exposure to future regulatory changes, or different interpretations of the current regulations, can significantly impact the already selected beneficial use practice. In that case, potential, unplanned, liabilities for the CCR owners are an implied risk which must be addressed to the extent that regulatory bodies can ensure protection.

15. **The elapsed time during post closure care requires clarity.** Under CCR facilities closure regulations, a post-closure care period of 30 years is required after closure is certified. For any facility monitored under a post-closure care program, that has shown compliance, there is a significant deterrent to reopen that unit without clarity on whether the post-closure care clock starts anew. When beneficial use is preferred by all parties, and re-opening is considered, the regulatory program and incentives will need to provide elapsed time clarity and encourage the extraction of new resources and their applications, such as cement replacement, thus reducing the overall carbon emissions of concrete.

SUPPORTING MATERIALS:
APPENDICES AND REFERENCES

The appendices contain glossaries of technical terms used in this report and detailed technical and scientific information in support of this report.

Appendix 1: Author Biography

Dr. Michael Karmis

Managing Partner, Michael Karmis, Ph.D., P.E., LLC

Dr. Michael Karmis retired at the end of 2021, after almost 44 years of service to Virginia Tech. For his contributions, he was recognized by the university as the Stonie Barker Professor Emeritus of Mining Engineering and Director Emeritus of the Virginia Center for Coal and Energy Research (VCCER). He now also serves as Managing Partner of Michael Karmis, Ph.D., P.E., LLC.

Dr. Karmis has authored or co-authored over 180 scientific papers and has directed more than 60 major research projects, funded by government agencies, foundations and the private sector. His expertise is in the broad space of sustainable development of energy and mineral resources, including the areas of geomechanics, health and safety, mining systems, carbon management and energy planning. He is familiar with the Appalachian coal industry and served since the early 1980s as a researcher and consultant to a number of companies and agencies operating in that area, providing advice on mine planning, health and safety, ground control, mine subsidence prediction and management, carbon management and waste storage design, monitoring and control. In addition, at Virginia Tech, Dr. Karmis directed numerous funded projects addressing these topics. Of particular interest is the use of coal and fly ash waste storage facilities to recover Carbon Ore (CO), Rare Earth Elements (REE) and Critical Minerals (CM). The US Department of Energy program known as CORE-CM, awarded the Central Appalachian coalfield region to the project Evolve-Central Appalachia, which was developed and led by Dr. Karmis as the Principal Investigator. The emphasis of this on-going project is to reduce or eliminate coal and ash waste streams and generate new products and industries using sustainable engineering practices and concepts which can make a significant contribution to the economic development of Southwest Virginia and the Central Appalachian coal communities.

As the Director of the Virginia Center for Coal and Energy Research (VCCER), Dr. Karmis managed an interdisciplinary center established by state legislation and provided leadership in developing research initiatives, educational programs and public service activities. In that role, he worked closely with electricity generation providers, energy fuels producers, transmission and infrastructure developers and the public. As an advisory body to the Virginia Governor and General Assembly, the VCCER participates in energy planning within the Commonwealth of Virginia. He has been involved in the development of pumped storage hydropower, hydrogen production/transmission/storage, geothermal energy, and solar cell component analysis.,. Dr. Karmis directed the first CO_2 sequestration assessment in Virginia, including geological and terrestrial, under the US Department of Energy National Energy Technology Laboratory's (NETL) and the Southern States Energy Board (SSEB) Regional Carbon Sequestration Partnerships. His recent efforts have also included international projects on Ventilation Air Methane (VAM), sponsored by the US Environmental Protection Agency's (EPA) "Methane to Market-M2M" and "Global Methane Initiative-GMI."

A Professional Engineer (P.E.) in the USA and a recognized Competent Person by the Society for Mining, Metallurgy and Exploration, Inc. (SME), Dr. Karmis is an active consultant to the global mining and energy industries, academic and research institutions, government agencies, engineering companies, and financial and legal firms. As Registered Member of SME, he is qualified to perform mineral resources/reserve consulting and reporting. He served as the 2002 President of SME and as the 2008 President of the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME). He is currently serving as an Associate Member of the SSEB. Dr. Karmis is an Honorary Member of AIME, a Distinguished Member of SME, and the recipient of numerous awards and recognitions from major scientific, educational, professional and industrial organizations.

Appendix 2: Glossary of Terms

The Glossary is separated into three sections, terms specific to coal waste, those specific to coal ash and basic minerals terms.

1. Coal Waste Terminology

Source: Some definitions below were extracted from "*Coal Waste Impoundments: Risks, Responses, and Alternatives*" Report of the Committee on Coal Waste Impoundments, Committee on Earth Resources, National Research Council, (2002)

ABANDONED IMPOUNDMENT
An impoundment that is not in operation and is closed. It has been filled to capacity and reclaimed.

ACTIVE IMPOUNDMENT
An impoundment that is in operation and receiving slurry.

AQUITARD
A low permeability geologic horizon that restricts the migration of water under ordinary hydraulic gradients.

BEACH
The subaerial accumulation of the coarser fraction deposited from slurry.

BIOMINING
A process of using microorganisms (microbes) to extract metals of economic interest from rock ores or mine waste. Biomining techniques may also be used to clean up sites that have been polluted with metals.

BLACK WATER
Water mixed with fine coal refuse.

BONE
Typically, no combustible material found above, below or in partings between layers of coal.

COAL MIDDLINGS
By-products of the coal washing / beneficiation process that include the intermediate density material after separating low density clean coal and high density reject (rock). Can be re-processed to recover high BTU material.

FINES
An informal term referring to fine particles, either product or waste, resulting from processing and preparation; usually less than 100 mesh (150 micrometers) and greater than 325 mesh (45 micrometers).

FOOTPRINT OF THE EMBANKMENT
The area of natural ground to be covered by the embankment.

FREEBOARD
The difference in elevation between the embankment crest or spillway invert (bottom) and the water pool elevation in an impoundment.

FRENCH DRAIN
Small underground channel filled with permeable materials used to convey water passively.

GOB
Space left by the coal mining process into which waste is packed or the immediate roof caves **(*Note:*** *Known, in other English-speaking countries and their related literature, with the term* ***GOAF*****).**

GOB PILE (also see **REFUSE)**
A surface accumulation of waste material, that includes coal rejects, rock or bone, or other unmarketable materials which are separated during the cleaning process.

HYDRAULIC HEAD
The height of the free surface of a body of water above a given subsurface point, or pressure against the dam from the weight of the slurry (as used in the NRC report).

IMPOUNDMENT
The entire structure used for coal slurry waste disposal, including the embankment, basin, beach, pool, and slurry (as used in the NRC report).

INACTIVE IMPOUNDMENT
An impoundment that is not in operation or receiving slurry. Inactive impoundments may receive slurry in the future, becoming active again, and therefore, have not been closed permanently.

LIQUEFACTION
The transformation of a solid material, such as loosely packed sediment or cohesionless soil, into a fluid mass due to increased pore pressure and reduced effective stress.

MOISTURE CONTENT
The percentage of water in a waste slurry. Calculated as the weight of water divided by the weight of the dried solids multiplied by 100 (as used in the NRC report).

MONITORING
Observing, regulating, and evaluating a system to ensure that it is operating properly.

PRE-LAW IMPOUNDMENT
An impoundment that has not been in operation since promulgation of the 1977 Surface Mining Control and Reclamation Act (SMCRA) regulation. These impoundments are reclaimed under the Abandoned Mine Lands Program.

OUTCROP
The intersection between a geologic formation (e.g., coal seam) and the Earth's surface.

OUTCROP BARRIER (**BOUNDARY/PERIMETER PILLAR**)
Distance between the coal outcrop and the furthest extent of underground mine workings in the direction of the outcrop.

PARTINGS
Thin sedimentary layers that follow a surface of separation between thicker units of rock.

PERMEABILITY
The capacity of a porous medium to permit flow of a given fluid.

PHREATIC SURFACE
The groundwater interface or a zone of saturation where the water pressure is equal to atmospheric pressure.

PHYTOMINING
Production of a `crop' of a metal by growing high-biomass plants that accumulate high metal concentrations. Phytomining for a range of metals is a real possibility, with the additional potential of the exploitation of ore bodies that it is uneconomic to mine by conventional methods.

PIPING
Seepage through embankments, which can lead to failure by internal erosion.

POOL
Area of free-standing water separated from the slurry discharge point by the Beach; it may contain a low percentage of fines and ultra-fines, and suspended and unconsolidated solids.

PROBABLE MAXIMUM PRECIPITATION
The theoretical, greatest depth of precipitation for given duration that is possible over a particular drainage basin.

REFUSE (OR GOB) PILE
Area where coarse waste material (larger than 28 mesh, 800 micrometers) is disposed.

RUN-OF-MINE
Raw mined material, unaltered from what is transported out of the mine.

SIDE SLOPE
Natural embankment.

SLIMES
Material in the waste stream smaller than 325 mesh (45 micrometers) and composed mainly of clay or clay-like particles; have high moisture content or the ability to retain water.

SLURRY
A mixture of water and solids (less than 28 mesh, 800 micrometer, particle size) prepared for handling as a liquid for processing and disposal.

SOLIDS CONTENT
(as used in this report) The percentage of solids in a waste slurry.

STACKING
Disposing of dewatered coal waste in “stacks” or layers (from 4–6 inches to 1–3 feet in thickness) piled on top of each other without an embankment.

STARTER DAM
The initial embankment constructed as the first stage of a staged embankment construction system.

TAILINGS
Fine particle waste streams from either coal preparation (note: rarely used) or other mineral processing plants (note: commonly used).

TAILINGS DAM
(as used in this report) A structure constructed to contain fine particle waste streams from other mineral processing plants.

TOE DRAIN
A zone of permeable materials constructed at the downstream toe of an embankment to collect and convey water from the downstream region of the embankment.

ULTRAFINES
Fine particles, either product or waste, resulting from the processing or preparation of any mineral; particles are smaller than 325 mesh (45 micrometers).

UPSTREAM CONSTRUCTION DAM
A method of staged embankment construction where the embankment centerline is moved upstream with subsequent embankment raises.

OTHER IMPORTANT DEFINITIONS FOR THIS STUDY

A. Virginia Department of Energy - Additional Definitions Consistent with House Bill 657/Senate Bill 120

WASTE COAL
Usable material that is a by-product of previous coal processing operations.

GOB PILES
Coal waste left in place after cleaning/screening, without consideration of location or stability. The exception to this definition is a site where gob material has been graded to a stable configuration and capped with soil by Virginia Energy or its predecessor agency. These features are mostly AML eligible.

REFUSE IMPOUNDMENTS
Area where coal waste was placed in a stable configuration behind a constructed barrier with the sole purpose of storing the waste material. These features occur mostly on permitted, or formally permitted, sites and are not eligible for AML (Title IV) funds. Removal of this material would require a Title V permit.

B. Power Plant Terminology Related to Waste Coal Supply

WASTE COAL
Any coal-derived fuel that has no economic value in the current metallurgical or steam markets and which, without the power plant's unique ability to convert it to energy, would be disposed of as a waste. This includes, but is not limited, to mining waste (overburden), coal preparation plant waste, pond fines, and road construction waste

GOB COAL
GOB is waste that was disposed of in the environment prior to the 1977 implementation of SMCRA, and which is often associated with environmental impacts of the ground, surface waters and air.

2. Coal Ash Terminology

Source: Some key definitions below were extracted from the "*2015 Coal Combustion Residuals (CCR) Rules, Section 257.53* and from the Commonwealth of Virginia rules below:

- *9VAC20-81-95. Identification of solid waste.*
- *9VAC20-81-97. Beneficial use demonstrations.*
- *9VAC20-85. Coal combustion byproduct regulation.*

BAGHOUSE
A facility constructed at coal-fired power plants to remove particulate matter (fly ash) from the flue gas by the use of fabric filter bags that mechanically trap particulate (fly ash) carried in the flue gases; a facility that removes fly ash from the flue gas by the use of fabric filter bags.

BENEFICIAL USE OF CCR
Means the CCR meet all of the following conditions: (1) The CCR must provide a functional benefit; (2) The CCR must substitute for the use of a virgin material, conserving natural resources that would otherwise need to be obtained through practices, such as extraction; (3) The use of the CCR must meet relevant product specifications, regulatory standards or design standards when available, and when such standards are not available, the CCR is not used in excess quantities; and (4) When unencapsulated use of CCR involving placement on the land of 12,400 tons or more in non-roadway applications, the user must demonstrate and keep records, and provide such documentation upon request, that environmental releases to groundwater, surface water, soil and air are comparable to or lower than those from analogous products made without CCR, or that environmental releases to groundwater, surface water, soil and air will be at or below relevant regulatory and health-based benchmarks for human and ecological receptors during use.

COAL COMBUSTION BYPRODUCTS (CCB)
Means residuals, including fly ash, bottom ash, boiler slag, and flue gas emission control waste produced by burning coal. CCB includes both CCR and other non-CCR wastes identified in this definition.

COAL COMBUSTION RESIDUALS (CCR)
Means fly ash, bottom ash, boiler slag, and flue gas desulfurization materials generated from burning coal for the purpose of generating electricity by electric utilities and independent power producers.

CCR FACILITY
Means all contiguous land, and structures, other appurtenances, and improvements on the land, used for treating, storing, disposing, or otherwise conducting solid waste management of

CCR. A facility may consist of several treatment, storage, or disposal operational units (e.g., one or more landfills, surface impoundments, or combinations of them).

CCR LANDFILL OR LANDFILL

Means an area of land or an excavation that receives CCR and which is not a surface impoundment, an underground injection well, a salt dome formation, a salt bed formation, an underground or surface coal mine, or a cave. For purposes of this subpart, a CCR landfill also includes sand and gravel pits and quarries that receive CCR, CCR piles, and any practice that does not meet the definition of a beneficial use of CCR.

CENOSPHERES

A portion of the fly ash, previously referred to as the floating fraction, occurring on the surface of fly ash ponds. They can be harvested, processed and marketed for beneficial uses, including performance enhancement of products, such as paints, coatings, adhesives etc.

CLOSED

Means placement of CCR in a CCR unit has ceased, and the owner or operator has completed closure of the CCR unit in accordance with § 257.102 and has initiated post-closure care in accordance with § 257.104.

DISPOSAL

Means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste as defined in section 1004(27) of the Resource Conservation and Recovery Act into or on any land or water so that such solid waste, or constituent thereof, may enter the environment or be emitted into the air or discharged into any waters, including groundwaters. For purposes of this subpart, disposal does not include the storage or the beneficial use of CCR.

ENCAPSULATED BENEFICIAL USE

Means a beneficial use of CCR that binds the CCR into a solid matrix that minimizes its mobilization into the surrounding environment.

FOSSIL FUEL COMBUSTION PRODUCTS

Means coal combustion byproducts as defined in this regulation, coal combustion byproducts generated at facilities with fluidized bed combustion technology, petroleum coke combustion byproducts, byproducts from the combustion of oil, byproducts from the combustion of natural gas, and byproducts from the combustion of mixtures of coal and "other fuels" (i.e., co-burning of coal with "other fuels" where coal is at least 50% of the total fuel). For purposes of this definition, "other fuels" means waste-derived fuel product, auto shredder fluff, wood wastes, coal mill rejects, peat, tall oil, tire-derived fuel, deionizer resins, and used oil.

INACTIVE CCR SURFACE IMPOUNDMENT
Means a CCR surface impoundment that no longer receives CCR on or after October 19, 2015, and still contains both CCR and liquids on or after October 19, 2015.

LEACHATE
Liquid, including any suspended components, that has percolated through or drained from a pile of solid material such as ash or coal. Leachate may enter the groundwater and contaminate drinking water supplies.

OWNER
Means the person(s) who owns a CCR unit or part of a CCR unit.

RECOGNIZED AND GENERALLY ACCEPTED GOOD (*also BEST*) ENGINEERING PRACTICES
Means engineering maintenance or operation activities based on established codes, widely accepted standards, published technical reports, or a practice widely recommended throughout the industry. Such practices generally detail approved ways to perform specific engineering, inspection, or mechanical integrity activities.

SOLID WASTE MANAGEMENT OR MANAGEMENT
Means the systematic administration of the activities which provide for the collection, source separation, storage, transportation, processing, treatment, or disposal of solid waste.

STATE DIRECTOR
Means the chief administrative officer of the lead state agency responsible for implementing the state program regulating disposal in CCR landfills, CCR surface impoundments, and all lateral expansions of a CCR unit.

SURFACE IMPOUNDMENT
Means a natural topographic depression, man-made excavation, or diked area, which is designed to hold an accumulation of CCR and liquids, and the unit treats, stores, or disposes of CCR.

UPPERMOST AQUIFER
Means the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary. Upper limit is measured at a point nearest to the natural ground surface to which the aquifer rises during the wet season.

WASTE BOUNDARY
Means a vertical surface located at the hydraulically downgradient limit of the CCR unit. The vertical surface extends down into the uppermost aquifer.

3. Basic Minerals Terms

Source: Some key definitions below were extracted from *"Minerals, Critical Minerals, and the US Economy",* Report of the Committee on Critical Mineral Impacts of the US Economy, Committee on Earth Resources; National Research Council (2008).

BY-PRODUCT
Material of some economic value produced in a process that is focused on extracting another material. For example, indium is a byproduct of zinc processing.

CRITICALITY
Minerals criticality incorporates factors such as import reliance, source of supply and risk and impact of supply interruption.

CRITICAL MINERALS
Those that are both essential in use and subject to considerable supply risk.

GRADE
The relative quantity or percentage of the commodity or element of interest in a unit volume of mineralized rock.

MINERAL DEPOSIT
A mineral occurrence of sufficient size and grade that it might, under favorable circumstances, be considered to have economic potential.

MINERAL OCCURRENCE
Any concentration of ore or economic mineral found in bedrock or as float but that are too low grade or for other reasons are not considered potentially economic.

MINERAL RESERVE
That part of the reserve base which could be economically extracted or produced at the time of determination with existing technology.

MINERAL RESERVE BASE
That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. It is the in-place demonstrated resource from which reserves are estimated.

MINERAL RESOURCE
A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the

concentration is currently or potentially feasible. An "identified resource" is a resource whose location, grade, quality, and quantity are known or estimated from specific geologic evidence.

MINERALIZATION
The process or processes by which a mineral or minerals are introduced into a rock, resulting in a valuable or potentially valuable deposit.

ORE
A naturally occurring material from which one or more minerals of economic value can be extracted at a reasonable profit.

ORE BODY
A continuous, well-defined mass of material of sufficient ore content to make extraction economically feasible.

ORE DEPOSIT
A mineral deposit of such grade, tonnage, or value that the minerals can be extracted, processed, and distributed at a profit.

RARE EARTH ELEMENTS
A series of 15 metallic elements, from lanthanum (atomic number 57) to lutetium (71) that occur as oxides in the Earth's crust. These elements are not especially rare, but their concentrations are low. Three other elements (yttrium, thorium, and scandium) are sometimes also considered rare earth elements (see also diagram at the end of this section).

STRATEGIC MINERAL
A mineral associated almost exclusively with national security and military needs, or requirements during national emergencies.

SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM)
Materials used as a partial replacement of portland cement to improve both fresh and hardened concrete properties.

THE ENERGY ACT OF 2020 DEFINNITION OF "CRITICAL MINERAL"
Combines the earlier CRITICAL and STRATEGIC definitions from above into
"*a non-fuel mineral or mineral material essential to the economic or national security of the US and which has a supply chain vulnerable to disruption*". Critical minerals are also characterized as serving an essential function in the manufacturing of a product, the absence of which would have significant consequences for the economy or national security.

Appendix 3: Notes from USGS 2022 report

The USGS 2022 list of critical minerals is available at: https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals.

This list Includes 50 mineral commodities critical to the US economy and national security. The agency notes that the list was "…determined using the most up-to-date scientific methods to evaluate mineral criticality. The new list contains 15 more commodities compared to the nation's first list of critical minerals created in 2018." The new list splits the rare earth elements and platinum group elements into individual entries rather than including them as "mineral groups." The list is dynamic and depends on advances in technology, mining cost and pricing, market conditions and geopolitical factors. For example, the 2022 list of critical minerals adds nickel and zinc to the list while removing helium, potash, rhenium and strontium.

A periodic table that includes rare earths is shown in Figure 24.

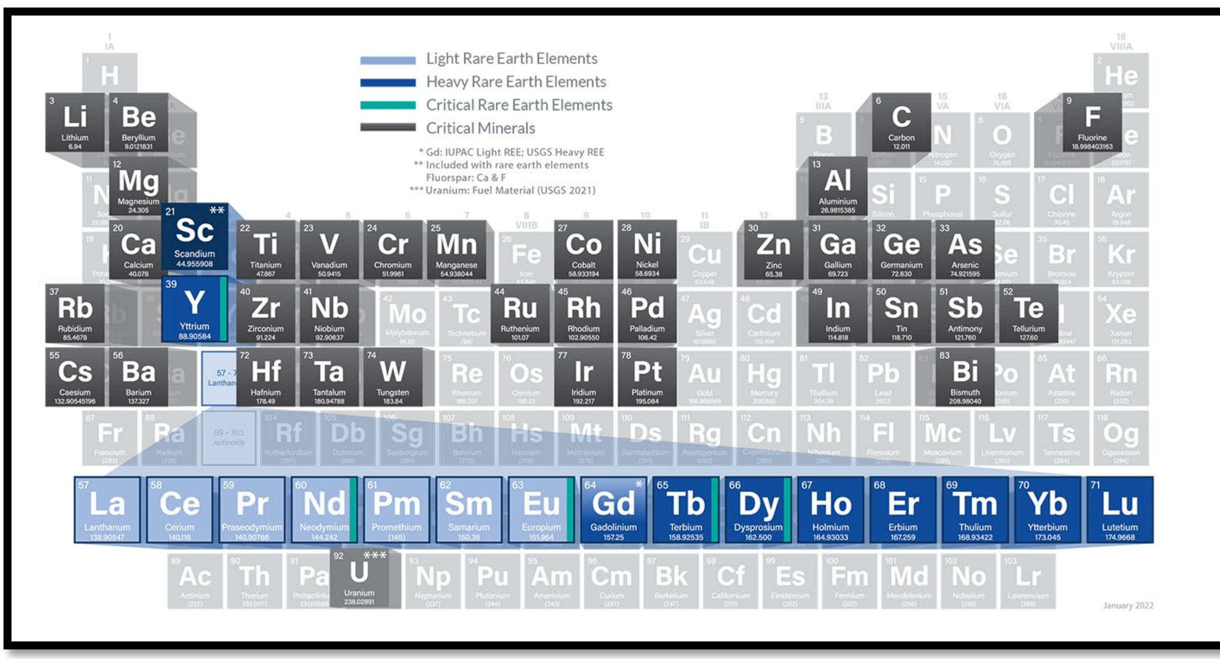


Figure 24: Rare Earths (Source: Minerals Sustainability Division, DOE)

Appendix 4: Gob Pile Property Data

Table 4: Median values for some physical and chemical properties of coarse coal refuse from Southwest Virginia

Samples were taken from five active piles and 22 abandoned piles (Stewart (1990) and continued observations by Daniels et al. (2018) through the mid-2000s)

Parameter	Median Value
Physical properties, whole refuse	
% material > 2 mm diameter	60%
Fine-earth fraction: % material < 2 mm diameter	40%
Physical properties, fine-earth fraction	
% sand-sized (2.000-0.050 mm)	60%
% silt-sized (0.050-0.002 mm)	22%
% clay-sized (< 0.002 mm)	15%
Soil textural class	sandy loam
Chemical properties, whole refuse	
Plant-available water	0.8%
pH	4.16
EC	0.04 S m-1
Cation exchange capacity	3.65 cmolc kg-1
Available phosphorus (P)	7.6 ppm
Potential acidity (acid-base accounting)	10.2 tons $CaCO_3$/1,000 tons refuse
Potential acidity (H_2O2)	27.8 tons CaCO /1,000 tons refuse

Table 5: Total elemental composition of coal refuse materials in Southwest Virginia

Descriptive statistics of the total elemental composition of 27 coal refuse materials sampled from southwestern Virginia by Stewart and Daniels (1992), compared to estimates for world soils.

	SW Virginia Coal Refuse[a]			World Soils[b]	
Element				**Median**	**Range**
----------g/kg----------					
SiO_2	391	408	202-552	714	536-750
AlO_2	128	133	62-196	155	22-656
FeO_2	41	42	22-77	60	11-864
K_2O	28.9	30	9.9-48.8	34	1-72
NaO	3.1	3	0.5-5.9	11	1-13
MgO	5.6	4.8	1.5-17.8	8	1-10
CaO	2.1	0.5	0.1-19.2	19	10-700
----------mg/kg[c]----------					
Cu	55	51.3	36.9-90.4	20	2-100
Zn	70.3	65.1	21.6-125.6	50	10-300
Ni	39.2	38.8	17.6-55.9	40	10-1,000

[a]Data from Stewart and Daniels (1992), Daniels and Stewart (2000).

[b]World soils' estimates from Helmke (1999), converted to an oxide basis.

[c]Minor metals are reported on a mass/ion basis and not on an oxide basis

Appendix 5: High-Value Carbon Products Production from Waste Coal Piles and Gob Piles

Graphite

Graphite has been produced from coals of different ranks, including anthracite, bituminous, and lignite in bench scale. To prepare graphite, coals are normally first pulverized to <75 µm (Wang et al., 2020; Xing et al., 2018; Zhu et al., 2019), and the pulverized products sometimes need to undergo a de-ashing step depending on their ash contents (Wang et al., 2020). A certain amount of mineral matter existing in coal can serve as catalysts that promote the graphitization reaction (Wang et al., 2020). Thus, complete removal of mineral matter from coal is unnecessary. For example, a lithium-ion battery anode graphite was successfully prepared from a high-rank bituminous coal with 7.35% ash content (Xing et al., 2018). After pulverization and de-ashing, coal can be prepared into graphite following two general approaches: one approach is thermal treatment at a temperature beyond 2500°C and/or under high pressure, and the other approach is at a temperature slightly lower than or close to 2500°C with the addition of catalysts. Based on the operation conditions, it can be inferred that the first approach is energy intensive, while the second approach consumes a lot of catalysts, which may deteriorate the purity and affect the application of produced graphite.

Recently, molten-salt electrolysis at mild temperatures (800-1000°C) has been used to produce graphite from coals (Zhu et al., 2019). In this process, coals are pelletized and used as the cathode, while graphite is used as the anode. The cathode and anode are placed in a molten salt (e.g., $CaCl_2$), and electrolysis occurs in the presence of an external power source. During the electrolysis process, the oxygen-containing functional groups in coals are removed, and the carbon atoms in coals are re-organized to form graphite. Compared with the other two approaches, the energy consumption for graphite production from coals is noticeably reduced using the molten-salt electrolysis method. The effect of mineral matter content on the performance of this method has not been reported in the literature. Existing studies prefer to purify coals and other carbon sources into high-purity carbons for molten-salt electrolysis (Figure 25) (Peng et al., 2017; Zhu et al., 2019).

Besides molten-salt electrolysis, another new method using microwaves to produce graphite from coals has also been recently reported. In this process, coal powders are pressed onto metal foils and sealed in a controlled environment followed by microwave irradiation. Microwave irradiation induces sparking to generate high temperature, which leads to the formation of graphite. The metal-assisted microwave treatment has been proved in the laboratory, but is still a long way from commercialization given the difficulty in controlling the sparking process and the limited throughput capacity. A summary of existing methods for graphite production from coal is shown in Figure 26. Among these methods, molten-salt electrolysis is most promising since it requires a mild temperature and molten-salt electrolysis has been widely used in the metal refining industry.

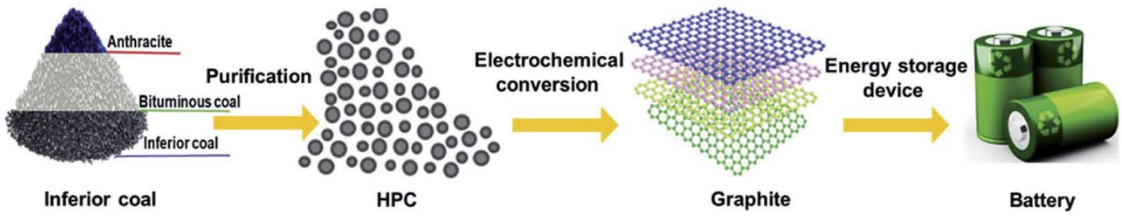


Figure 25: Schematic of the conversion of coals into graphite through molten-salt electrolysis (Zhu et al., 2019)

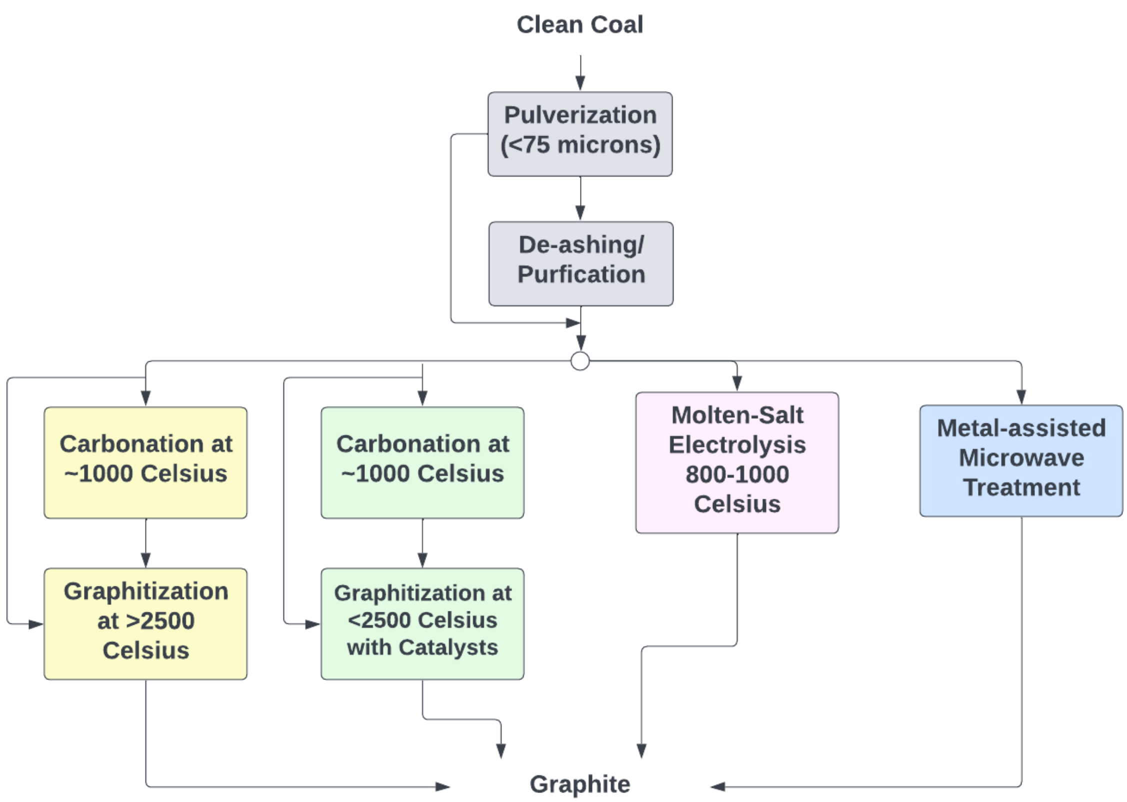


Figure 26: Different approaches for graphite production from coal (from left to right: thermal treatment, catalyst-assisted thermal treatment, molten-salt electrolysis, and metal-assisted microwave treatment)

Activated Carbon

Activated carbon has been widely used to remove a wide variety of organic and inorganic pollutants dissolved in aqueous media or from gaseous environments. Activated carbons have been commercially produced from different raw materials of organic origin, such as wood, peat, lignin, cellulose, nut shells, and coals (beginning from brown coals and ending with anthracites). The production of activated carbon from coal normally consists of two steps: carbonization and activation. In the carbonization step, coal is pyrolyzed at 400-950ºC in inert atmosphere (Cuhadaroglu & Uygun, 2008; Hsu & Teng, 2000; Linares-Solano et al., 2000; Pietrzak et al., 2006; Teng & Lin, 1998; Teng et al., 1998). Following the carbonization process, the obtained char can be activated with carbon dioxide or steam at a high temperature (e.g., 80ºC) (Linares-Solano et al., 2000). In addition, activation can also be performed prior to carbonization by mixing the coal with chemical reagents (e.g., H_3PO_4, $ZnCl_2$, KOH) at high temperature (Hsu & Teng, 2000).

Given the fact that activated carbons have been commercially produced from coals of different ranks, it can be predicted the clean coal recovered from waste coal piles/gob piles can also be used for producing activated carbon. However, to facilitate applications, the particle size of activated carbon should not be too fine or too coarse. Activated carbon is commonly available in 8 by 30 mesh (largest), 12 by 40 mesh (most common), and 20 by 50 mesh (finest). Therefore, the fine clean coal (typically finer than 100 mesh) recovered from waste coal piles/gob piles is not suitable for activated carbon preparation. The clean coal of medium size fraction (8-50 mesh) recovered from waste coal piles/gob piles is recommended for use in producing activated carbon.

Carbon Foam

Carbon foam is a sponge-like carbon material, having many advanced features, such as lightweight (0.2-0.8 g/cm^3), high temperature tolerance (up to 300 ℃ in inert atmosphere), high strength (up to 20 MPa, compression), and adjustable thermal conductivity (Chen et al., 2006). This combination of features makes carbon foam a next generation material that can be used in various fields, such as electrodes for batteries and catalyst support for high temperature reactions. Coal and coal solvent extracts are suitable precursors of carbon foam, while coal tar pitch must be pretreated to modify its plastic property and viscosity. Various treatment methods, including vacuum distillation, solvent extraction, heat treatment, and acid treatment, have been employed. Direct use of the clean coal recovered from waste coal piles/gob piles in the preparation of carbon foam is preferable to converting the clean coal into extractants or coal tar pitch. The conversion process will complicate the overall carbon foam preparation circuit and increase the preparation cost.

According to the literature, the self-foaming method is the most widely used to prepare carbon foam from coal (Chen et al., 2006; Yu et al., 2019). In this method, foaming is carried out in a pressure vessel by heating coal up to 400-500ºC in an inert atmosphere. The resultant foams are calcined at 1000°C or higher in an inert atmosphere to increase the strength and further remove the volatiles. As Table 5 shows, coals used for carbon foam preparation in the literature are mostly bituminous coals. Most coals in the Appalachian Coal Basin are bituminous coals; therefore, coals in waste coal piles/gob piles in Virginia are suitable for preparing carbon foams. In addition, as Table 5 shows, coals are normally pulverized to fine powders for carbon foam preparation. Therefore, the fine coals generated from the processing of waste coal piles/gob piles can be used for carbon foam preparation without or with limited pulverization.

Table 6: Specifications of selected coals reported in the literature used for carbon foam preparation (Chen et al., 2006; Rodríguez & García, 2012; Wang et al., 2022)

Precursors	**Rank**	**Size**	**Proximate analysis (% of weight), as received**		
			Moisture	**Volatile**	**Ash**
Kingwood coal	Bituminous	n/a	0.84	34.48	11.44
Bakerstown coal	Bituminous	n/a	1.60	30.01	6.32
Poellton coal	Bituminous	n/a	2.02	28.02	10.75
Lower War Eagle coal	Bituminous	n/a	1.95	27.27	10.75
Pondfork coal	Bituminous	<212 µm	n/a	17.5	10.00
Fenxi coal	Bituminous	<212 µm	n/a	29.83	6.46
A bituminous coal	Bituminous	<100 mesh	n/a	n/a	n/a

Graphene/Graphene Oxide

The most commonly employed method for large scale preparation of graphene is based on Hummers' method, consisting of the oxidation of graphite leading to exfoliation of individual sheets of graphene oxide followed by a reduction step. Many studies on graphene/graphene oxide preparation from coal have been reported in the literature. Some methods are summarized in Table 6. As shown, the synthesis of graphene/graphene oxide is complex, which involves coal purification, ultrafine grinding, oxidation by reacting with strong acids, multiple steps of washing, etc. Therefore, it is difficult to produce graphene/graphene oxide onsite while cleaning up waste coal piles/gob piles.

Table 7: Selected methods used for graphene/graphene oxide preparation from coal

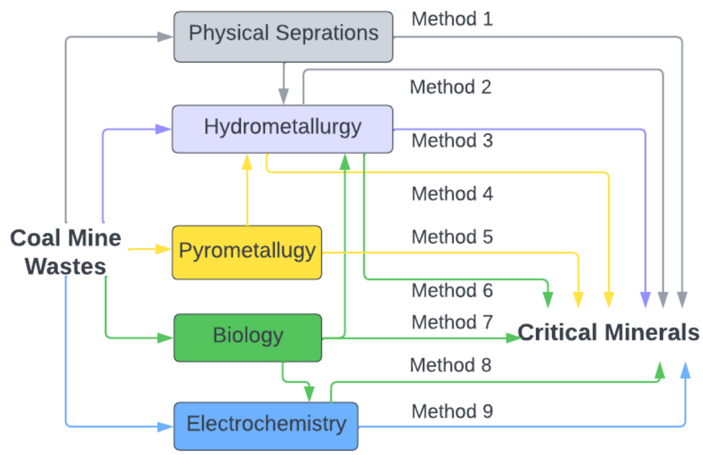
Feed	Product	Method	Reference
Anthracite	Graphene oxide (GO)	Coal Purification: milled to <125 µm, reacted with HCl and HF to remove metal impurities and minerals GO Preparation: mixed in concentrated HNO_3 at 120°C (coal oxidation), water washing, ultra-sonication (exfoliation), centrifuging, lyophilization, thermal reduction at 800°C	(Chen et al., 2006; Rodríguez & García, 2012; Wang et al., 2022)
Coal (6.6% ash, 9.5% moisture, 35.4% volatile, 48.5% fixed carbon	GO	Coal Purification: ball milling GO Preparation: mixed with $NaNO_2$ and concentrated H_2OS_4 at room temperature for 15 h followed by 80°C for 6 h, centrifuging, washing, drying	(Sahoo et al., 2022)
Anthracite or bituminous	Highly oxidized graphene quantum dots	Heating ground coal powders in a mixture of 1:1 fuming sulfuric acid with 18-24% excess SO_3 with stirring at 0 °C, fuming HNO_3 is added at 0°C for another 60 min, heating at 65 °C and followed by 70°C, cellulose membrane dialysis, filtration, size classification	(Nilewski et al., 2019)
Bituminous coal	Graphene quantum dots	Sonicating in concentrated H_2OS_4 and HNO_3, followed by heating at 100 or 240°C for 24 h, cooled down and poured into a beaker containing ice, adding NaOH to neutral pH, filtration, dialysis	(Ye et al., 2013)
Coal	Graphene	Direct laser scribing	(Zhang et al., 2019)

Appendix 6: Critical Minerals Production

Critical minerals include aluminum, antimony, arsenic, barite, beryllium, bismuth, cerium, cesium, chromium, cobalt, dysprosium, erbium, europium, fluorspar, gadolinium, gallium, germanium, graphite, hafnium, holmium, indium, iridium, lanthanum, lithium, lutetium, magnesium, manganese, neodymium, nickel, niobium, palladium, platinum, praseodymium, rhodium, rubidium, ruthenium, samarium, scandium, tantalum, tellurium, terbium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium (2022 Final List of Critical Minerals, 2022).

Many studies on critical minerals recovery from coal-based materials have been reported in the literature, which have been summarized in several review articles (Eterigho-Ikelegbe et al., 2021; Fu et al., 2022; Zhang et al., 2020; Zhang et al., 2015). A high-level summary of existing methods is shown in Figure 27. Conventional recovery methods have certain limitations. For example, intensive size reduction is required to sufficiently liberate critical minerals from host particles for concentration through physical separations, a large amount of chemicals is consumed to dissolve critical minerals through hydrometallurgical methods, and a lot of energy is needed for high-temperature treatment through pyrometallurgical methods. Therefore, biological and electrochemical methods are advantageous over conventional physical, hydrometallurgical, and pyrometallurgical approaches in terms of small carbon footprint and relatively low recovery cost. Besides the methods listed in Figure 27, other methods such as supercritical CO_2 extraction(Das et al., 2018; Song et al., 2021), plasma arc gasification (Renew, 2017), plasma separation (Gueroult et al., 2018), and fast Joule heating (Deng et al., 2021) have been tested or have the potential to be used for critical mineral recovery from coal-based materials. However, these methods suffer from disadvantages such as high recovery cost (e.g., supercritical CO_2 extraction), high energy consumption (e.g., plasma arc gasification), and low technology readiness level (e.g., plasma separation and fast Joule heating). Therefore, using biological and electrochemical methods that can produce green chemicals with green energy to recover critical minerals from coal-based materials is the most promising approach.

Based on the existing industrial practice of bioleaching, the coarse refuse and fine refuse can be biologically processed through heap leaching and tank leaching, respectively (Figure 28). After leaching, leach solutions containing critical minerals are obtained, which can be processed through bulk solvent extraction, micro-fluidic solvent extraction, precipitation, and electrochemical separation. A major challenge faced by all the existing methods, including the biological method, is that a large amount of solid waste is generated due to the low critical mineral contents in coal-based materials. In this case, even if all the critical minerals are recovered, the majority of coal refuse will end up as solid waste. To address this challenge, the concept of phytoming can be introduced. The coal refuse after bioleaching can be used as a substrate of plants that have high accumulation capacity of critical minerals, such as pokeweed for REEs (Dinh et al., 2022). The combination of biological method and phytoming can achieve simultaneous critical mineral recovery and solid waste remediation. In addition, during the phytomining process, the remaining critical minerals after bioleaching can be continuously recovered into the plants, which can be further recovered at the end of season.



Method	REE Recovery	REE Purity	Cost	Carbon Emissions
1	Low	Low	High	High
2	Medium	High	High	Medium
3	High	High	High	Medium
4	High	High	High	High
5	High	Medium	High	High
6	Medium	High	Medium	Low
7	Medium	Low	Medium	Low
8	Medium	High	Medium	Low
9	Medium	Medium	Medium	Medium

Figure 27: High-level summary of existing methods used for critical mineral recovery from coal-based materials

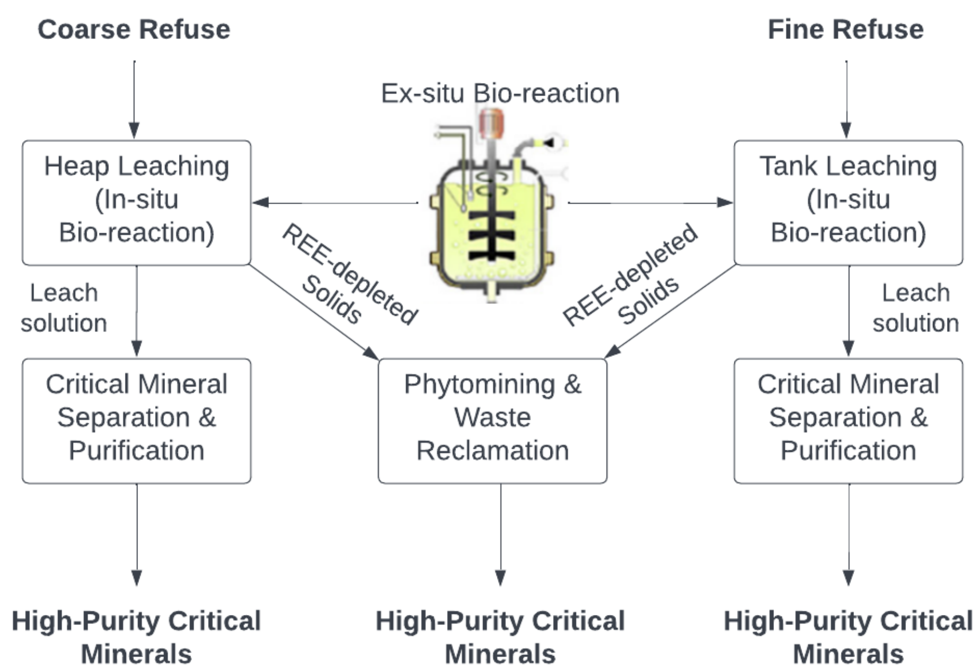


Figure 28: The best approach to recover critical minerals from coal refuse

Appendix 7: Fertilizer Production from Gob Piles

The conventional coal-to-urea (CTU) process uses gasification to decompose coals into CO_2 and H_2 through gasification and then the H_2 is reacted with N_2 separated from the atmosphere to form ammonia. Finally, synthetic ammonia is reacted with a portion of the CO_2 generated from gasification to obtain urea. As an alternative to CTU, a coal direct chemical looping hydrogen production process (CDCLTU) has also been used to produce urea from coal. In this process, coal gasification is replaced with chemical looping to generate H_2 and CO_2. The production cost and carbon emissions of CDCLTU are lower than those of CTU (Zhou et al., 2022), see Figure 29.

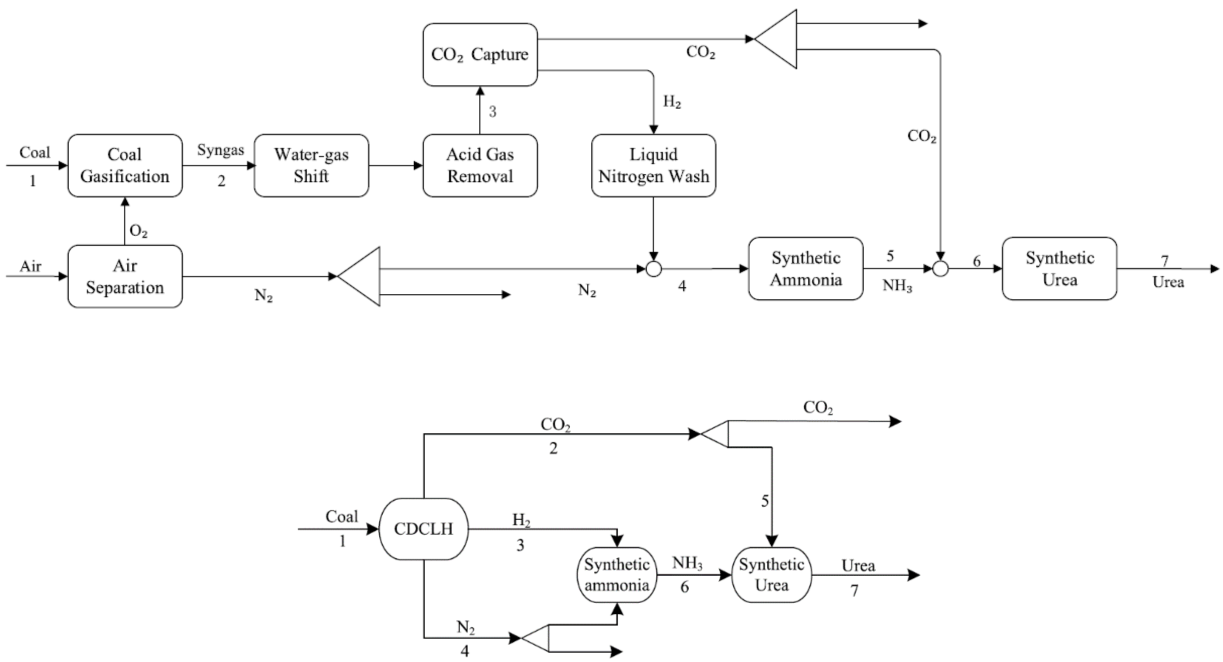


Figure 29: Simplified block diagrams of CTU (top) and CDCLTU (bottom) (Zhou et al., 2022)

An additional process is to use nutrients and biostimulants in order to enhance plant nutrition efficiency, abiotic stress tolerance and crop quality as depicted in Figure 30.

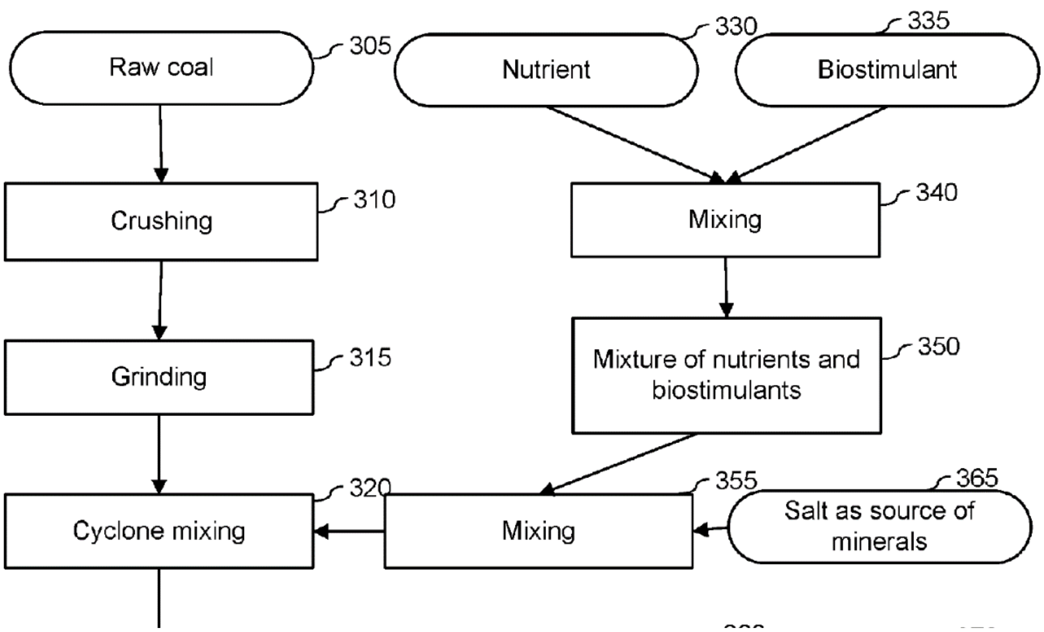


Figure 30: Direct preparation of fertilizer by mixing coal with other materials (Saputra, 2017)

Appendix 8: Location of CCR Facilities in the Commonwealth

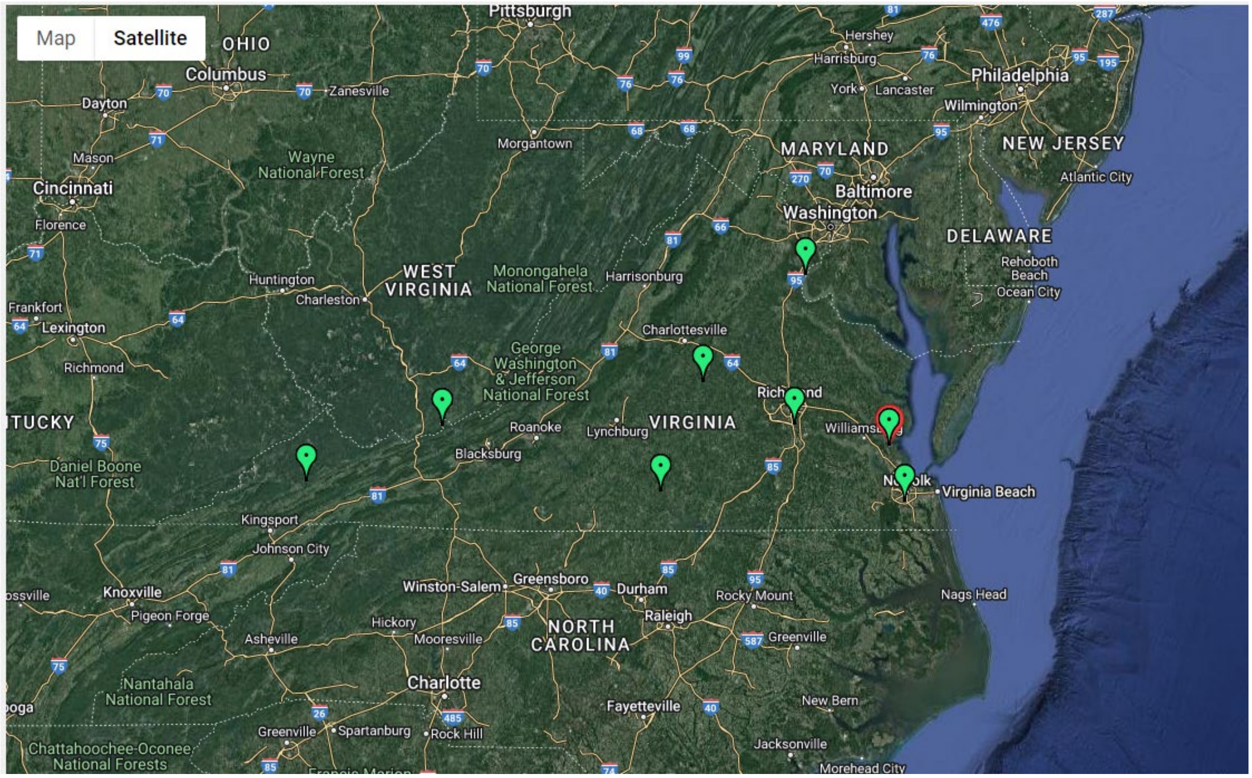


Figure 31: Locator Map for Power Stations

Stations are listed in the following order in Section 2.2:

1. American Electric Power – Clinch River Plant
2. APCO – Glen Lyn
3. Dominion – Bremo Power Station
4. Dominion – Chesapeake Energy Center
5. Dominion – Possum Point Power Station
6. Dominion – Yorktown Power Station
7. Dominion Energy – Chesterfield Power Station
8. Dominion / ODEC – Clover Power Station

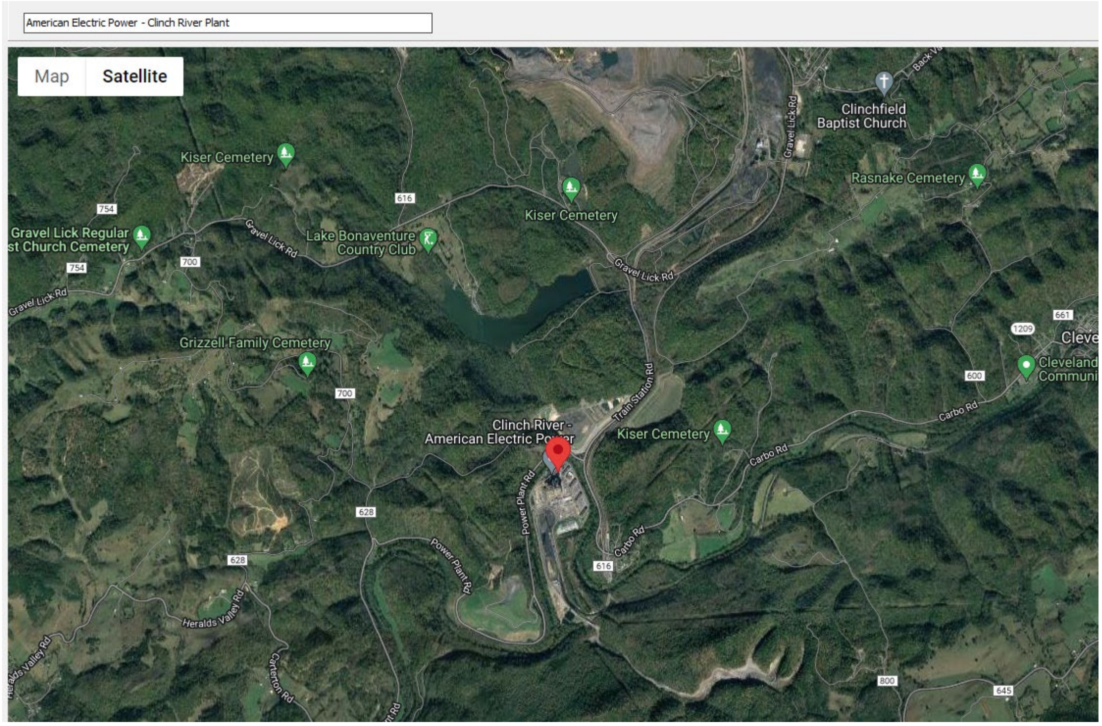


Figure 32: American Electric Power – Clinch River Plant Map

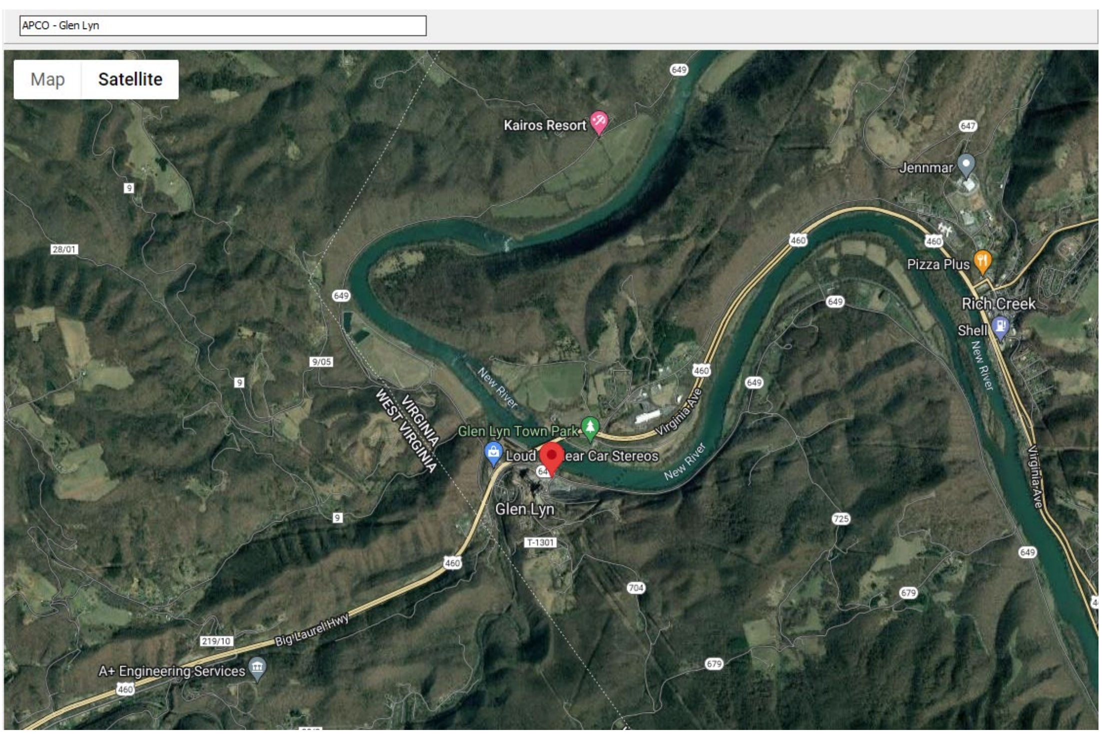


Figure 33: APCO - Glen Lyn Plant Map

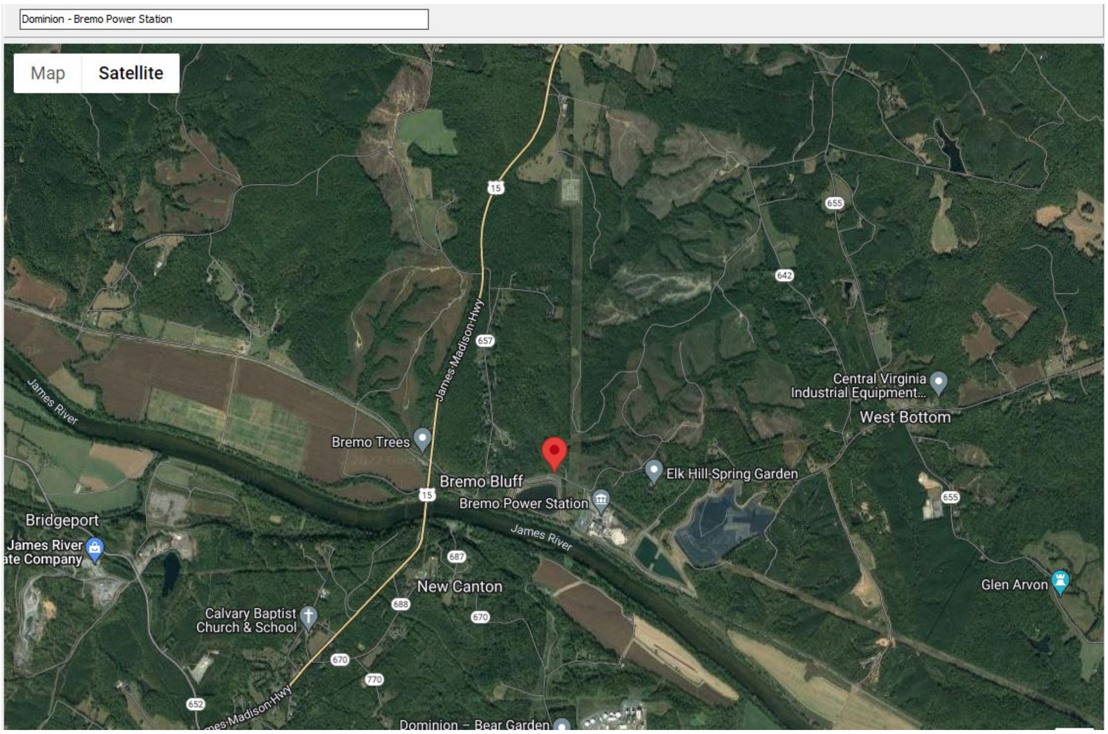


Figure 35: Dominion Energy – Bremo Power Station Map

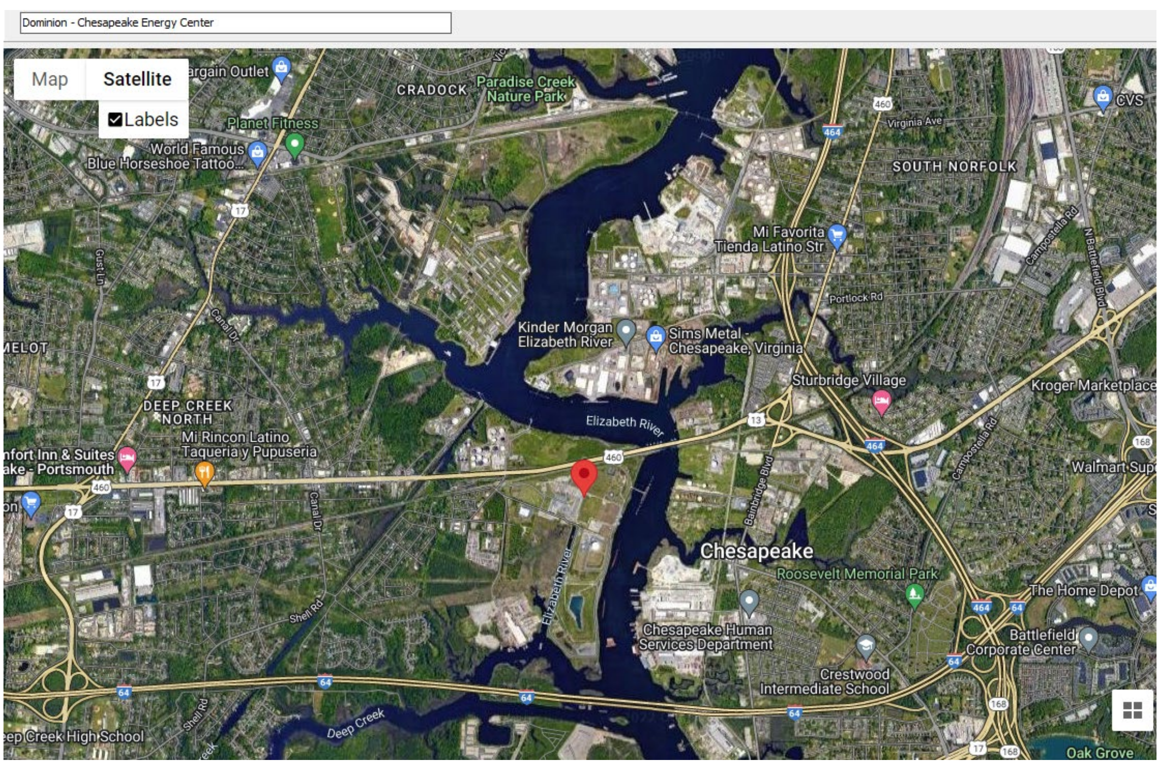


Figure 34: Dominion Energy – Chesapeake Energy Center Map

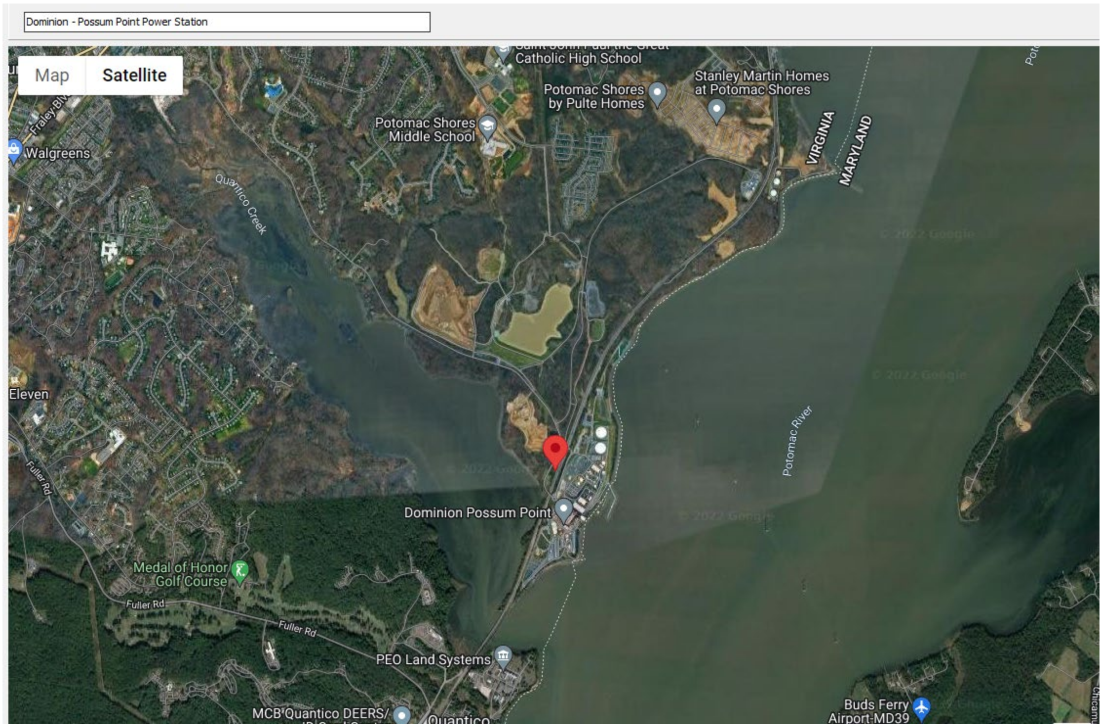


Figure 36: Dominion Energy – Possum Point Power Station Map

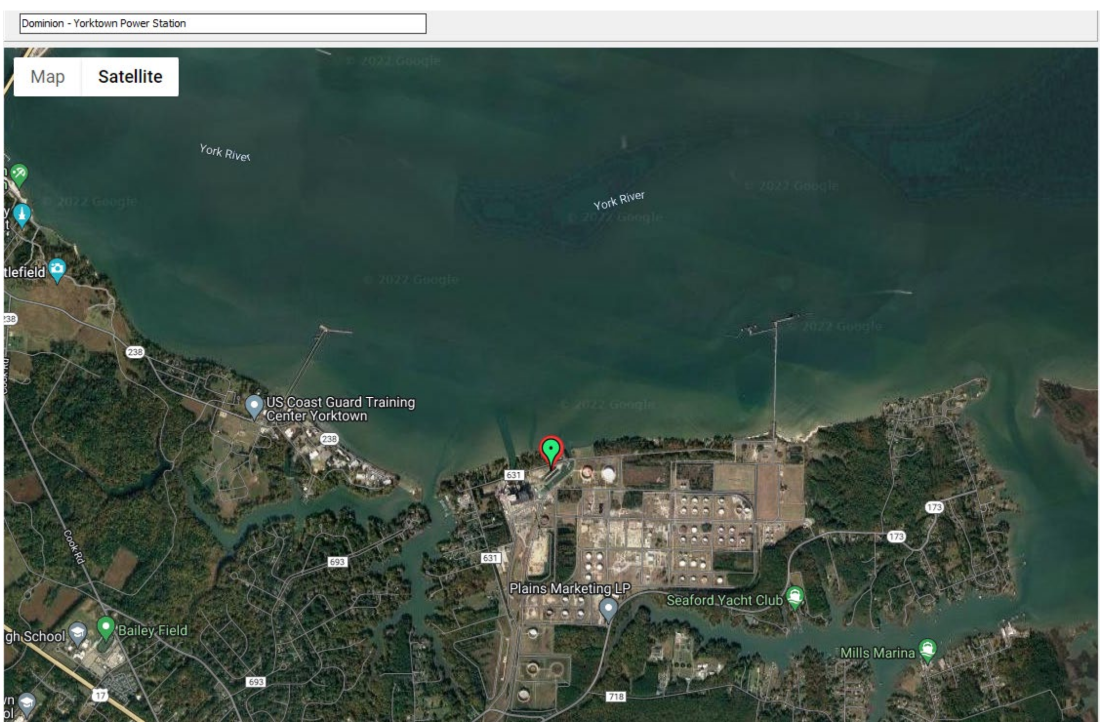


Figure 37: Dominion Energy – Yorktown Power Station Map

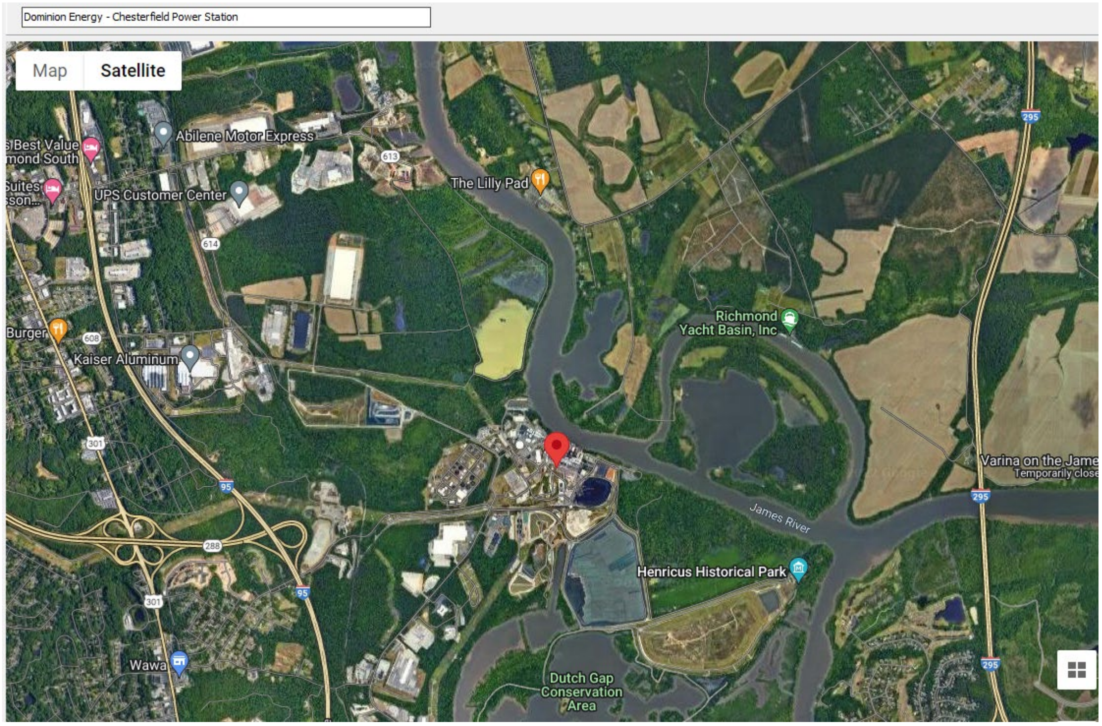


Figure 38: Dominion Energy – Chesterfield Power Station Map

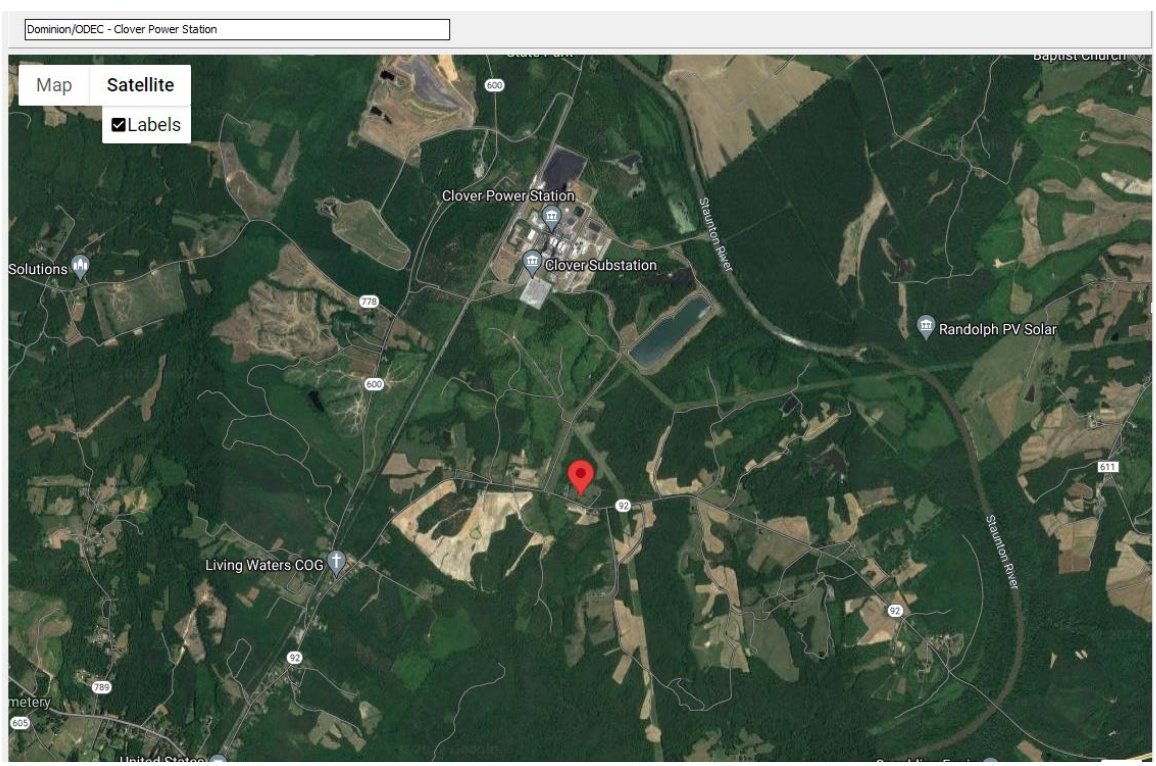


Figure 39: Dominion/ Old Dominion Electric Cooperative – Clover Power Station Map

Appendix 9: Characterization of Coal Ash

Table 8: Fly ash compositions (%) (Blissett & Rowson, 2012; Cao et al., 2008; Diaz et al., 2010; Franus et al., 2015; Liu et al., 2004; Ma et al., 1999; Mishra & Das, 2010; Moreno et al., 2005; Mupambwa et al., 2015; Wilczyńska-Michalik et al., 2014)

Reference	Ash Type	Country	SiO2	Al2O3	TiO2 (Ti2O3)	Fe2O3	CaO	MgO	MnO (Mn2O3)	NiO	SO3	K2O	Na2O	P2O5	LOI
Ma et al., 1999	Fly ash	China	50.0	37.1	n/a	3.1	3.4	0.5	n/a	n/a	0.7	n/a	0.6	n/a	0.31
			47.6	23.4	n/a	14.6	1.2	0.7	n/a	n/a	0.9	n/a	1.1	n/a	0.82
			50.6	20.7	n/a	12.4	2.3	1.0	n/a	n/a	n/a	n/a	1.2	n/a	0.49
			45.4	29.3	n/a	11.9	1.2	0.6	n/a	n/a	0.2	n/a	2.0	n/a	0.85
			46.0	19.5	n/a	4.1	3.9	5.7	n/a	n/a	n/a	n/a	n/a	n/a	1.83
			53.2	22.1	n/a	8.4	3.1	0.8	n/a	n/a	0.8	n/a	1.4	n/a	0.82
			44.2	23.6	n/a	4.8	18.2	1.2	n/a	n/a	0.8	n/a	n/a	n/a	0.74
			58.6	29.3	n/a	2.4	2.4	0.8	n/a	n/a	1.2	n/a	0.6	n/a	0.35
			31.4	14.6	n/a	4.0	31.0	2.7	n/a	n/a	2.7	n/a	n/a	n/a	1.30
Moreno et al., 2005	Fly ash	Europe	55.2	23.3	0.9	6.9	4	2.5	0.1	n/a	0.4	3.8	0.7	0.3	1.9
			42.6	35.6	1.6	2.6	8.4	2.1	0.1	n/a	0.6	0.6	0.3	1.7	3.8
			49.5	26.7	0.9	12.3	2.3	0.9	0.03	n/a	0.3	1.9	0.3	0.2	4.7
			49.2	17.6	0.5	10.4	11.8	2	0.1	n/a	2.2	0.4	0.4	0.2	5.2
			48.3	23.9	0.8	16	5.4	1	0.03	n/a	0.8	1.4	0.2	0.2	2
			52.3	28.5	1	5.9	2	1.5	0.1	n/a	0.1	4	0.5	0.4	3.7
			51.2	25.5	0.9	7.5	2.8	2	0.1	n/a	0.6	3.9	0.8	0.4	4.3
			44.1	23.2	0.9	14.3	8.9	1.8	0.1	n/a	1.1	2.6	0.3	0.8	1.9
			41.5	30.1	0.6	12.6	5.6	1.6	0.1	n/a	1.4	1.9	0.6	0.2	3.8
			48.9	30.6	0.8	7.2	3	1.6	0.03	n/a	0.3	3.9	0.6	0.1	3
			58.6	27.4	0.7	7.3	0.8	1	0.1	n/a	0.2	2.4	0.3	0.1	1.1
			46.8	24.8	0.9	9	6.8	3.7	0.1	n/a	1	2	1.2	0.7	3
			45.3	25	1.3	8.8	6.4	1.4	0.03	n/a	1.3	1.1	0.8	1	7.5
			53.3	26.1	1.8	7.4	3.1	0.6	0.1	n/a	0.5	0.6	0.1	1.5	4.8
			59.6	27	1.4	3.3	0.5	0.9	0.03	n/a	0.2	2.9	0.3	0.1	3.7
			51.3	28.9	1.5	8.4	1.8	1	0.03	n/a	0.5	2.5	0.5	0.2	3.3
			45.2	26.5	1.3	7.1	6.1	1.6	0.03	n/a	1.1	1.2	0.8	1.1	8.1
			52.4	25.8	1.3	7	5.6	1.6	0.1	n/a	0.6	1.4	0.7	0.9	2.8
			53.2	26	1.3	8.6	2.4	1.6	0.1	n/a	0.6	2.7	0.5	0.3	2.7
			28.5	17.9	1	8.4	27.3	3.8	0.03	n/a	8.6	1	0.2	0.3	3
			48.2	25.9	1.3	8.8	2.3	1.5	0.1	n/a	0.6	2.6	0.5	0.3	7.9
			50.8	33.4	2.6	6.4	2.4	0.8	0.03	n/a	0.3	0.7	0.4	0.3	1.9
			41.7	29	1.7	3.8	10	2.4	0.1	n/a	0.9	0.8	0.5	1.5	7.6
Liu et al., 2004	Fly ash	China	50.89	18.83	0.21	16.45	6.97	0.84	n/a	n/a	2.86	0.87	0.62	1.49	n/a
			57.72	20.04	0.52	11.47	3.26	0.78	n/a	n/a	2.31	0.92	0.58	1.26	n/a
			48.31	26.11	0.28	13.26	4.78	0.69	n/a	n/a	2.15	0.84	0.71	1.09	n/a
Cao et al., 2008	Fly ash	China	43.7	44	1.5	3.5	0.9	0.4	n/a	n/a	0.7	0.9	0.3	0	n/a
Diaz et al., 2010	Fly ash	US	37.77	19.13	n/a	7.33	22.45	4.81	n/a	n/a	1.56	n/a	1.8	n/a	0.17
			55.61	19.87	n/a	4.52	12.93	2.49	n/a	n/a	0.49	0.86	0.67	n/a	0.22
			58.52	20.61	n/a	9.43	5	1.86	n/a	n/a	0.49	n/a	0.52	n/a	0.05
			48.7	16.6	n/a	6.93	18.72	3.91	n/a	n/a	0.85	n/a	n/a	n/a	0.49
			55.07	28.61	n/a	6.22	1.97	1.08	n/a	n/a	0.19	2.63	0.38	n/a	1.82
Mishra & Das, 2010	Fly ash	India	60.23	31.15	2.42	4.29	0.76	0.1	n/a	n/a	n/a	0.96	n/a	0.09	0.52
			61.61	31.08	2.07	2.7	0.61	0.22	n/a	n/a	n/a	1.06	n/a	0.64	0.56
			59.71	32.42	2.21	3.56	0.95	0.18	n/a	n/a	n/a	0.74	n/a	0.22	0.47
Wilczyńska-Michalik et al., 2014	Fly ash	Poland	54.96	25.08	1.09	6.53	2.44	2.15	0.07	n/a	n/a	3.18	1.09	0.29	1.8
			48.11	23.14	0.88	7.38	2.65	2.21	0.07	n/a	n/a	2.95	0.85	0.26	11.2
			53.26	21.42	0.86	9.03	2.7	2.43	0.1	n/a	n/a	2.66	0.66	0.25	6.3
			60.66	24.79	1.05	5.58	0.37	1.53	0.05	n/a	n/a	3.66	0.73	0.11	1.2
Franus et al., 2015	Fly ash	Poland	53.25	26.67	1.15	5.98	2.88	2.29	0.07	n/a	n/a	2.82	0.74	0.47	3.4
			53.24	26.14	1.05	6.08	3.05	2.35	0.06	n/a	n/a	2.87	0.79	0.54	3.6
			50.84	25.65	1.12	6.07	4.03	2.49	0.08	n/a	n/a	2.58	0.83	0.45	5.6
			52.18	23.02	1.02	8.88	5.1	3.66	0.14	n/a	n/a	2.73	0.82	0.31	1.9
			52.32	26.26	1.06	6.19	2.88	2.42	0.09	n/a	n/a	3	1.05	0.45	3.9
			52.12	32.19	1.38	5.17	1.16	1.29	0.02	n/a	n/a	2.87	0.49	0.43	2.6
			49.74	27.62	1.13	5.43	3.8	2.85	0.06	n/a	n/a	3.34	1.29	0.91	3.5
			46.51	20.86	0.88	7.62	4.56	3.29	0.11	n/a	n/a	2.28	0.99	0.37	12.3
			32.21	16.88	0.76	7.53	7.58	3.29	0.09	n/a	n/a	1.82	1.13	0.42	28
			35.7	26.57	2.22	4.52	23.44	1.72	0.03	n/a	n/a	1.1	1.46	0.18	2.9
			42.63	17.74	1.2	4.61	29.45	1.17	0.04	n/a	n/a	0.19	0.16	0.1	2.4
			51.35	3.97	0.61	6.3	29.9	5.94	0.34	n/a	n/a	0.22	0.15	0.18	0.5
Mupambwa et al., 2015	Fly ash (Statisics for different countries)	Europe	28.5 – 59.7	12.5 – 33.6	0.5 – 2.6	2.6 – 21.2	0.5 – 28.9	0.6 – 3.8	0.03 – 0.2	n/a	n/a	0.4 – 4.0	0.1 – 1.9	0.1 – 1.7	n/a
		China	35.6 – 57.2	18.8 – 55.0	0.2 – 0.7	2.3 – 19.3	1.1 – 7.0	0.7 – 4.8	n/a	n/a	n/a	0.8 – 0.9	0.6 – 1.3	1.1 – 1.5	n/a
		India	50.2 – 59.7	14.0 – 32.4	1.0 – 2.7	2.7 – 14.4	0.6 – 2.6	0.1 – 2.1	0.5 – 1.4	n/a	n/a	0.8 – 4.7	0.5 – 1.2	0.1 – 0.6	n/a
		South Alfrica	50.1 – 67.0	23.4 – 27.0	1.3 – 1.6	2.7 – 4.7	6.4 – 8.7	1.9 – 2.7	0.04 – 0.5	n/a	n/a	0.5 – 0.9	0 – 1.3	0.3 – 0.89	n/a
Blissett & Rowson, 2012	Fly ash (Statisics for different countries)	Europe	28.5–59.7	12.5–35.6	0.5–2.6	2.6–21.2	0.5–28.9	0.6–3.8	0.03–0.2	n/a	0.1–12.7	0.4–4	0.1–1.9	0.1–1.7	0.8–32.8
		US	37.8–58.5	19.1–28.6	1.1–1.6	6.8–25.5	1.4–22.4	0.7–4.8	n/a	n/a	0.1–2.1	0.9–2.6	0.3–1.8	0.1–0.3	0.2–11.0
		China	35.6–57.2	18.8–55.0	0.2–0.7	2.3–19.3	1.1–7.0	0.7–4.8	n/a	n/a	1.0–2.9	0.8–0.9	0.6–1.3	1.1–1.5	n/a
		India	50.2–59.7	14.0–32.4	1.0–2.7	2.7–14.4	0.6–2.6	0.1–2.1	0.5–1.4	n/a	n/a	0.8–4.7	0.5–1.2	0.1–0.6	0.5–5.0
		Australia	48.8–66.0	17.0–27.8	1.3–3.7	1.1–13.9	2.9–5.3	0.3–2.0	n/a	n/a	0.1–0.6	1.1–2.9	0.2–1.3	0.2–3.9	n/a

Table 9: Bottom ash compositions (%) (Kurama et al., 2009; Liu et al., 2004; Muthusamy et al., 2020; Singh et al., 2020)

Reference	Ash Type	Country	SiO2	Al2O3	TiO2 (Ti2O3)	Fe2O3	CaO	MgO	MnO (Mn2O3)	NiO	SO3	K2O	Na2O	P2O5	LOI
Liu et al., 2004	Bottom Ash China	China	48.52	21.75	0.82	14.38	7.82	1.14	n/a	n/a	2.37	1.19	0.5	1.31	n/a
			60.71	18.46	0.91	9.42	4!.51	0.94	n/a	n/a	1.87	1.13	0.42	0.85	n/a
			48.16	26.31	0.72	12.86	6.26	0.85	n/a	n/a	1.96	1.03	0.63	0.9	n/a
Kurama et al., 2009	Bottom Ash	Turkey	54.5	15.4	n/a	11.16	4!.69	4.26	n/a	n/a	1.3	1.34	0	n/a	8.9
Muthusamy et al., 2020	Bottom Ash	Data from various literature sources	41.7	17.1	3.83	6.63	22.5	4.91	n/a	n/a	0.42	0.4	1.38	n/a	1.13
			61.8	17.8	0.88	6.97	3.19	1.34	n/a	n/a	0.79	2	0.95	0.2	3.61
			57.9	22.6	n/a	6.5	2	3.2	n/a	n/a	n/a	0.6	0.08	n/a	2.4
			60.7	18.3	0.95	6.56	3.25	1.28	n/a	n/a	0.82	2.12	0.89	n/a	4.13
			56	26.7	1.3	5.8	0.8	0.6	n/a	n/a	0.1	2.6	0.2	n/a	4.6
			54.8	28.5	2.71	8.49	4.2	0.35	n/a	n/a	n/a	0.45	0.08	0.28	2.46
			57.76	21.58	n/a	8.56	1.58	1.19	n/a	n/a	0.02	1.08	0.14	n/a	n/a
			47.53	20.69	n/a	5.99	4.17	0.82	n/a	n/a	1	0.76	0.33	n/a	n/a
			52.1	18.34	0.87	11.99	6.61	4.85	n/a	n/a	n/a	1.57	2.43	n/a	4.13
			62.32	27.21	2.15	3.57	0.5	0.95	n/a	n/a	n/a	2.58	0.7	n/a	n/a
			45.3	18.1	3.27	19.84	8.7	0.69	n/a	n/a	0.3	2.48	n/a	n/a	0.1
			55.1	28.1	n/a	8.3	1.1	0.3	n/a	n/a	0.3	1.5	n/a	n/a	3.9
			58.7	20.1	n/a	6.2	9.5	1.6	n/a	n/a	0.4	1	0.1	1	0.8
			52.2	27.5	1.53	6	5.9	1.7	n/a	n/a	n/a	0.6	1.3	0.74	1.8
			34	36	3.8	16.8	2.4	n/a	n/a	n/a	n/a	5.9	n/a	n/a	n/a
			48	20.1	1.11	8.77	7.11	3.13	n/a	n/a	n/a	n/a	n/a	n/a	8.1
			59.82	27.76	n/a	3.77	1.86	0.7	n/a	n/a	1.39	0.33	1.61	n/a	4.69
			52.5	17.65	2.17	8.3	4.72	0.58	n/a	n/a	n/a	n/a	n/a	n/a	4.01
			50.49	27.56	2.23	10.93	4!.19	1.24	n/a	n/a	0.1	0.82	0.57	0.24	1.11
			66.9	17.7	n/a	6.5	1.56	0.51	n/a	n/a	n/a	n/a	n/a	n/a	2.65
			47.1	23.1	1.2	5.7	7.8	1.5	n/a	n/a	1.5	5.3	0.7	n/a	2.52
			44.1	9.21	n/a	24.3	13	1.88	n/a	n/a	n/a	1.25	n/a	n/a	n/a
Singh et al, 2020	Bottom Ash	Data from various literature sources	49.3	34	2.01	5.8	5.06	0.99	0.05	n/a	0.24	0.87	<0.01	0.59	0.5
			60.1	27.2	1.55	1.7	4!.27	1.03	0.01	n/a	0.41	0.71	0.56	0.42	1.9
			46.3	10.7	0.93	17.3	3	0.36	0.05	n/a	3.42	2.53	2.48	0.11	8
			50.1	26.1	1.81	7.3	5.28	2.44	0.12	n/a	1.3	1.08	2.4	0.71	27.9
			53.1	29.5	1.8	4.3	6.66	1.25	0.08	n/a	0.29	1.04	0.27	2.35	19.3
			53.7	26.1	1.32	6.3	5.29	0.9	2.27	n/a	0.72	1.33	0.04	0.33	3.2
			59.6	22.8	0.94	5.6	3.11	0.87	n/a	n/a	0.4	1.28	0.45	0.04	n/a
			55.7	27	1.56	6.21	5.48	1.53	0.05	n/a	n/a	0.59	0.19	0.38	6.3
			49.2	23	n/a	5.3	6.38	1.17	n/a	n/a	0.29	0.91	0.32	n/a	11.2
			54.4	23	n/a	5.6	4!.66	3.49	n/a	n/a	0.72	0.69	0.83	n/a	3.9
			56.5	24.1	0.54	3.4	3.64	0.68	0.03	n/a	n/a	4.05	0.7	n/a	5.8
			51.9	32.8	1.89	6.3	2.7	1.1	n/a	n/a	n/a	2.11	0.33	n/a	0.2
			44.6	22.5	n/a	9.9	6.76	&98	n/a	n/a	2.52	0.6	0.22	n/a	3.8
			53.1	19.2	n/a	10.4	4.6	3.9	n/a	n/a	3	1.8	0.8	n/a	3.2
			49.1	30.8	n/a	6.1	1.46	2.46	n/a	n/a	4.2	3.86	0.63	n/a	0.8
			48.9	27.6	n/a	6.7	6.16	2.71	n/a	n/a	3.55	2.39	0.45	n/a	1.4
			41.5	18.9	0.71	6.3	16.41	3.66	0.03	n/a	1.05	0.86	9.12	0.41	0.4
			33	16	n/a	2	27.1	0.5	n/a	n/a	2.5	0.2	<0.10	n/a	n/a
			41.5	17.8	n/a	9.9	12.52	4.46	n/a	n/a	7.25	2.43	2.57	n/a	0.7

Table 10: Recommended and optional characterizations of coal fly ash

Test Method	**Component**
Recommend Physical Tests [A]:	
ASTM C109	Comprehensive strength of hydraulic cement mortars, psi [B]
ASTM C110	Heat rise (slaking rate), °C [C]
ASTM C191	Time of set, min [B]
ASTM C311	Amount retained on No. 325 sieve, %
ASTM C311	Strength activity index with Portland cement 7 days, % of control 28 days, % of control
ASTM C311	Water requirement, % of control [D]
ASTM C311	Specific gravity
ASTM C311	Increase in drying shrinkage, %
ASTM C311	Reactivity with cement alkalies, mortar expansion, % of control
ASTM C593	Amount retained on No. 200 sieve, %
ASTM C593	Amount retained on No. 30 sieve, %
ASTM C593	Lime pozzolan strength 7 days, psi Lime pozzolan strength 28 days, psi
ASTM C1827	Relative foam index
ASTM C1897	Cumulative heat release or bound water
Recommended Chemical Tests:	
ASTM C114	Sulfur trioxide (SO_3), % [E]
ASTM C311	Moisture content, %
ASTM C311	Loss on ignition, %
ASTM D3682, or D4326	Calcium oxide (CaO), %
ASTM D3682, or D4326	Magnesium oxide (MgO), %
ASTM D3682, or D4326	Silicon oxide (SiO2) plus aluminum oxide (Al2O3) plus iron oxide (Fe2O3), %
Optional Physical Tests (Limits to be specified only if applicable, by the purchaser)	
ASTM C25	Available lime index (ALI), % [F]
ASTM C311	Available alkalies as Na_2O, %
ASTM C400	pH [G]
ASTM C602	Calcium carbonate equivalent ($CaCO_3$), %
ASTM D6357	Trace elements (totals) (for example, sulfide, sulfite, and sulfate)
ASTM C441	Reduction in mortar expansion
DOE/NETL-2016/1794	REE content analysis
Infrared spectroscopy or thermogravimetry	Carbon content and forms of carbon

[A] Individual requirements may be specified by the purchaser if applicable to the project for which fly ash is to be used.

[B] Modification of Test Method C 109 to approximate proportion(s) of fly ash instead of cement; or fly ash in combination with other materials to be used on the project (that is, cement, lime, etc.) should be used.

[C] Modify Test Methods C 110 to a proportion of fly ash instead of lime. The fly ash to water ratio may need to be modified further to obtain measurable results.

[D] Comparisons of water requirements to a control material, used at an equal flow, may be useful to determine the relative water requirement.

[E] Fly ash replaces hydraulic cement in method.
[F] Fly ash replaces limestone in analysis.

[G] Fly ash replaces quicklime in method.

Appendix 10: Production of Construction Materials from Coal Ash

Table 11: Fly ash construction-related applications (1996; https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/cfa51.cfm#:~:text=The%20principal%20components%20of%20bituminous,loss%20on%20ignition%20(LOI).)

Applications	Quantity used		Percent of Total Used
	Million Metric Tons	Million Tons	
Cement production and/or concrete products	7.2	8.0	60
Structural fills or embankments	1.9	2.2	17
Stabilization of waste materials	1.7	1.9	14
Road base or subbase materials	0.63	0.7	5
Flowable fill and grouting mixes	0.27	0.3	2
Mineral filler in asphalt paving	0.15	0.2	2
Approximate Total	11.85	13.3	100

Table 12: Chemical requirements (ASTM C618)

Specifications	Class	
	F	C
SiO_2 plus Al_2O_3 plus Fe_2O_3, min, %	50.0	50.0
SO_3, max, %	5.0	5.0
Calcium oxide (CaO), max, %	18.0	>18.0
Moisture content, max, %	3.0	3.0
Loss on ignition, max, %	6.0 [A]	6.0

[A] The use of Class F pozzolan containing up to 12.0% loss on ignition may be approved by the user if either acceptable performance records or laboratory test results are made available.

Table 13: Physical requirements (ASTM C618)

Specifications	Class	
	F	C
Fineness:		
Amount retained when wet-sieved on 45 µm (No. 325) sieve, max, %	34	34
Strength activity index: [A]		
With Portland cement, at 7 days, min, percent of control	75 [B]	75 [B]
With Portland cement, at 28 days, min, percent of control	75 [B]	75 [B]
Water requirement, max, percent of control	105	105
Uniformity requirements		
The density and fineness of individual samples shall not vary from the average established by the ten preceding tests, or by all preceding tests if the number is less than ten, by more than:		
Density, max variation from average, %	5	5
Percent retained on 45 µm (No. 325), max variation, percentage points from average	5	5

[A] The strength activity index with Portland cement is not to be considered a measure of the compressive strength of concrete containing the fly ash or natural pozzolan. The mass of fly ash or natural pozzolan specified for the test to determine the strength activity index with Portland cement is not considered to be the proportion recommended for the concrete to be used in the work. The optimum amount of fly ash or natural pozzolan for any specific project is determined by the required properties of the concrete and other constituents of the concrete and is to be established by testing. Strength activity index with Portland cement is a measure of reactivity with a given cement and is subject to variation depending on the source of both the fly ash or natural pozzolan and the cement.

[B] Meeting the 7 day or 28 day strength activity index will indicate specification compliance.

Dry Separation Technologies

In the dry route, dry separation technologies are used, such as pneumatic separator and micron separator for size classification and cenosphere recovery (Hirajima et al., 2010; Petrus et al., 2011), ultrasonic sieving for size classification (Soong et al., 2002), and triboelectrostatic separation for unburned carbon removal (Ban et al., 1997). Contrast experiments showed that micron separator outperforms pneumatic separator (Petrus et al., 2011). As Figure 40 shows, a micron separator separates particles into coarse and fine fractions, which are routed to the underflow and overflow streams, respectively. Cenospheres in fly ash normally distribute in coarse fractions (Ghosal & Self, 1995); thus, they are recovered to the underflow stream. A process combining two stages of micron separator separation was tested (Petrus et al., 2011). As Figure 40 shows, fly ash was first separated at a cut-off size of 20 µm, and around 80% of cenospheres in the feed were recovered to the underflow. The underflow was then fed to a float-sink tank to concentrate the cenospheres. The overflow of the first micron separator was fed to a second-stage micron separator operating at a cut-off size of 5 µm. Qualified pozzolan (<5 µm) was produced in this step. Although water was used, only 12.2 % by weight of the feed fly ash was processed in the float-sink tank. Therefore, water consumption of this process is still lower than the wet route. Ultrasonic sieving combined with triboelectrostatic separation were also used to produce fly ash pozzolan with correct loss on ignition (LOI) and particle size (Soong et al., 2002). As Figure 41: Ash recovery versus loss on ignition (LOI) content for a fly ash separated through triboelectrostatic separation (Soong et al., 2002) shows, a simple separation of unburned carbon from fly ash was achieved at particle sizes of 149, 74, and 44 µm, and sieving could be utilized as the rough separation mechanism for fly ash. For example, LOI of the raw fly ash was around 11%, while LOI of the <44 µm fraction was only 6%. In addition, the LOI of each size fraction was further reduced through triboelectrostatic separation.

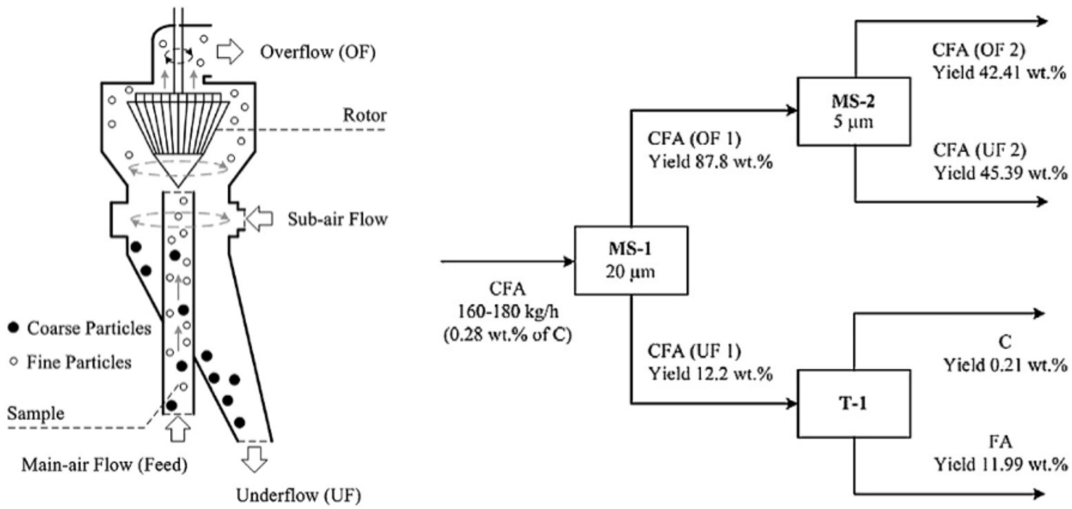


Figure 40: Schematic outline of micron separator (left) and a process to recover cenospheres from fly ash using micron separator (right) (Petrus et al., 2011)

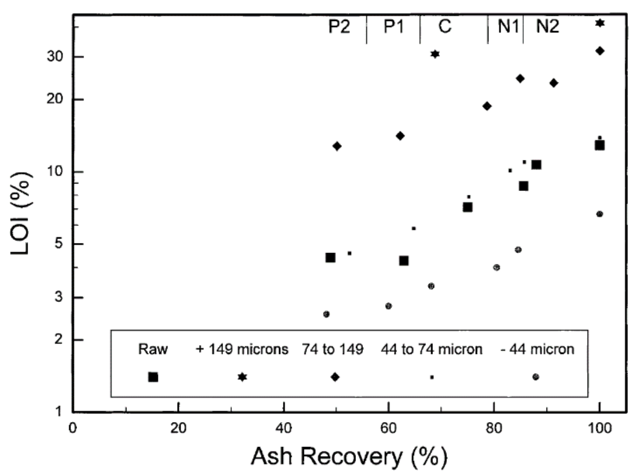


Figure 41: Ash recovery versus loss on ignition (LOI) content for a fly ash separated through triboelectrostatic separation (Soong et al., 2002)

Appendix 11: Production of Critical Minerals from Coal Ash

Table 14: A summary of the physical beneficiation of REE from coal fly ash (Columns Con, ER and Re represent the content, enrichment ratio, and recovery of REE in beneficiation concentrates)

Sample	Location	Recovery Method	Con ($\mu g\ g^{-1}$)	ER	Re (%)	Reference
Fly ash	China	Sieving	550	1.86	18.6	(Dai et al., 2014)
Fly ash	UK	Sieving	570	1.19	NA	(Blissett et al., 2014)
		Flotation – magnetic separation – size classification	637	1.26	NA	
Fly ash	USA	Sieving	593	1.16	30	(Bois et al., 2000)
		Density fractionation	522	1.02	95	
		Magnetic separation	666	1.06	0.7	
		Froth flotation	920	1.46	2	
Fly ash	USA	Sieving	670	1.08	38	(Lin et al., 2017)
		Magnetic separation	630	1.01	96	
		Density fractionation	1100	1.77	4	
Fly ash	USA	Magnetic separation - sieving	366	1.13	82	(Lin et al., 2018)
Fly ash	Poland	Sieving	271	1.17	50	(Lanzerstorfer, 2018)
Fly ash	China	Sieving	603	1.13	NA	(Pan et al., 2018)
Fly ash	China	Sieving	557	1.07	32	(Pan et al., 2019)
Fly ash	China	Sieving	499	1.04	57	
Fly ash	China	Sieving	896	1.15	35	(Kashiwakura et al., 2013)
		Magnetic separation	879	1.12	65	
		Density fractionation	855	1.09	30	
		Sieving – magnetic separation	1025	1.31	31	
Fly ash	Indonesia	Sieving	249	1.10	58	(Rosita et al., 2020)
Fly ash	Indonesia	Magnetic separation	278	1.12	92	

Appendix 12: Standardized Sampling and Testing Methods for Gob Piles and Coal Ash Storage Units

All sampling activities and testing procedures should be conducted under the supervision of qualified persons to ensure adherence to approved and recognized best practices and standards.

General Sampling Protocols for both Gob Piles and Coal Ash Storage Units

The general sampling protocols include the following steps:

1. Compile a map showing sample location, spacing, and identification.
2. Use clean tools to avoid sample contamination.
3. Locate the predetermined sample site in the field and identify the location with surveyor lath/stakes and flagging with sample site name.
4. Collect samples and immediately place each inside a sample bag. Place a label inside and attach label to the outside of the sample bag. Seal the sample bag. The labels should contain:
    a. Date and time of sampling
    b. Location coordinates
    c. Sample name
    d. Sample type (pit shovel, trench, drill sample)
    e. Sample material (coarse, fine or mixed refuse)
    f. Sample location (property or refuse disposal area name)
    g. Sample depth to/from depth and thickness for drill samples
    h. Name of sampler and sampling entity
5. Compile detailed notes of each sample in a field book including:
    a. Date and time of sampling
    b. Location coordinates
    c. Material type
    d. Color and material size
    e. Sample depth and size
    f. Surface soil material, thickness, and vegetation

g. Photograph the sample as well as its location. Maintain a photo log.

6. Sample Location:

a. Handheld GPS latitude and longitude coordinates are usually sufficient.

b. The sample location can be surveyed later by more accurate methods if needed.

Sampling Protocols for Gob Piles

Protocols for four different sampling methods are documented in this section:

- Pit/Trench Sampling of Coal Waste Piles
- Pit Sampling of Coal Waste by Hand and Shovel Procedure
- Trench Sampling by Excavation Equipment at Coal Waste Piles
- Drill Rig Sampling at Coal Waste Piles

Pit/Trench Sampling of Coal Waste Piles

Pit sampling can be accomplished by digging a hole by hand with a shovel or by excavating a trench with mobile backhoe or excavator. Pit samples should be collected in a predefined, systematic sampling plan. Samples collected on the top surface of the coal waste pile area should be on a grid pattern. If follow-up sampling is warranted, samples can be collected between the grid node sample sites. The top surfaces of coal waste pile areas might be capped with soil material. In these cases, a backhoe or excavator would be required to excavate down to the coal waste material to be sampled. Additionally, an excavator can sometimes be safely placed onto the coal waste pile embankment and reach laterally into unstable material to collect a sample. Samples should be collected along a vertical line down the face of the embankment. Sample spacing should be close enough to collect multiple samples in a bench lift. Preferably, three (3) lines of samples should be collected to determine trends and averages.

Pit Sampling of Coal Waste by Hand and Shovel Procedure

Pit sampling includes the following steps:

1. Follow the General Sample Protocol
2. Locate the predetermined sample site in the field and identify the location with surveyor lath/stake and flagging with sample name.
3. Dig a hole through soil material on the surface. Most slopes will have approximately 2 feet of topsoil or borrow material on the surface for vegetation growth.
4. Dig approximate 1.5 feet into the refuse material or where the coal waste material appears fresh and unweathered.

5. Collect 4-5 pounds of coal waste material from the bottom of the hole. Place the sample in a plastic sample bag 10 inches x 18 inches and 4 mils thick.
6. Document the site with notes and photography.
7. Reclaim the disturbed area.

Trench Sampling by Excavation Equipment at Coal Waste Piles

Trench sampling includes the following steps:

1. Follow the General Sampling Protocol.
2. Place the equipment at a level stable surface when prepared to excavate a trench for sampling. Pay particular attention to be certain the material is stable.
3. Excavate a trench to the desired depth for the sample. Samples can be collected from multiple horizons in the trench, a vertical composite of the material in the trench or a grab sample from the bottom of the trench dependent on the sample site.
4. Collect the desired sample with the equipment bucket. Do NOT enter the trench and collect a sample by hand. Remove a 4-5 lb. increment from the bucket. Place the sample increment into the plastic sample bag, label, and seal.
5. Backfill and level the sample trench. Restore the lath/stake for future reference.
6. Apply fertilizer, seed, and mulch in accordance with any agreement with the facility owner or operator.

Drill Rig Sampling at Coal Waste Piles

The pit and trench sampling provides a two-dimensional view of the coal waste material. To accurately calculate volumes of coal waste materials, the third, vertical dimension will need to be sampled. This sampling is best accomplished by vertically drilling into the coal waste. There are various methods for drilling and collecting samples. The common methods are based on using geotechnical soil drill rigs. The preferred method to collect the sample is with a continuous sampler hollow stem auger tool. Alternatively, split spoon/barrel auger sampling can collect a continuous sample or an 18-inch sample every 5 feet. Drilling characteristics of the material may require the use of sonic drilling equipment. Fine coal waste that is soft, elastic, and flows under pressure is difficult to drill and would require a sonic drill, or in the alternative, vibracoring. The drilling method used will need to be flexible and easily modified to accommodate the down-hole conditions. Drill site locations should be included in a predefined, systematic sampling plan. A minimum of three holes should be drilled in the same coal waste type to determine consistency and averages. Drill rig sampling includes the following steps:

1. Follow the General Sampling Protocol.
2. Obtain a cylindrical “core” sample 5-ft in length.

3. Place the sample in a tray to support the material and maintain the samples integrity.
4. Split the sample laterally down the center of the core.
5. Place each split or side or the core in separate plastic sample bags.
6. Label sample bags per protocol.
7. Repeat the process collecting continuous, 5-foot samples for the length of the drill hole.
8. Document the site with notes and photography.
9. Reclaim the disturbed area.

Coal Ash Sampling Protocols

The sampling protocol will greatly depend on the size and characteristics of the coal ash storage unit. Frequency of boreholes will subsequently vary from 1 per 10 acres to 1 per acre to assure reasonable density distribution of the collected data points. Two coal ash sampling protocols are detailed here (Kaladharan 2019) as examples: Method A: Stratified Random Sampling and Method B: Regular Grid-Based Sampling.

Method A: Stratified Random Sampling Approach (based on ASTM D5956)

This method relies heavily on historical utility data to identify any stratification that may exist within a landfill/impoundment. It assumes the fly ash properties to be homogenous within each stratum but will allow this assumption to be verified.

Step A.1: Based on the historical data and the pattern in which the fly ash was landfilled/impounded, the landfill/impoundment is to be divided into various strata. Fly ash from before and after any change in the power production parameters listed above shall be considered as belonging to different strata. Boundaries should be drawn as accurately as possible using the available information. Each individual stratum is assumed to be homogeneous, but this will be verified through steps A.2 to A.4 below. Steps A.2 to A.4 shall be repeated for each stratum in the landfill/impoundment.

Step A.2: In the plan view of each stratum (e.g., A and B in Figure 42 (a)), a 3×3 grid pattern shall be created such that the length and width of the stratum is divided into equal parts. The nine created grid blocks are numbered. A (minimum) three of the nine are chosen using a random number generator. Then a borehole sample is obtained from the X-Y center of each of these three random grid blocks. For the boundary grid blocks, the X-Y center may lie outside the landfill/impoundment. In such cases, the approximate center of the area within the landfill/impoundment should be sampled. The boring sample is taken from the entire depth of the stratum. At every (maximum) 1.5 m, the boring shall be split to create separate segments. For example, if the stratum is 5 m deep at a given point, then 4 segments are to be made, one from each of the following depths: 0-1.5 m, 1.5-3 m, 3-4.5 m, and 4.5-5 m. A (minimum) of two segments in each boring are chosen at random (this can be done by numbering the segments and using a random number generator). Therefore, a total of (minimum) six random segments will be available (minimum) three grid blocks × (minimum) two 1.5 m deep segments per grid block). The diameter of the boring must be large enough to obtain at least 2 kg of sample from each segment.

Step A.3: Each of the (minimum) six random segments shall be homogenized and tested according to the mandatory requirements of ASTM C618. The mean, range, standard deviation, and probability of exceeding or going below the ASTM C618 limit for each fly ash property must be determined by testing the six segments. Equations (1) and (2) may be used to calculate the probability of true average value of any individual fly ash property exceeding an upper or lower specification limits.

$$P\{Property > ASTM\ limit\} = P\left\{T_{n-1} < \frac{\bar{X}-USL}{S/\sqrt{n}}\right\} \tag{1}$$

$$P\{Property < ASTM\ limit\} = P\left\{T_{n-1} > \frac{\bar{X}-LSL}{S/\sqrt{n}}\right\} \tag{2}$$

Where n is the sample size (for six segments, $n = 6$), T_{n-1} is the statistical t-distribution with $n-1$ degrees of freedom, $\bar{X}$ is the sample average for every individual property, USL and LSL are the upper and lower specification limits, and S is the sample standard deviation.

Step A.4: A probability limit shall be selected based on the acceptable level of risk (say 5%). The properties for which the probability calculated in Step A.3 is below the acceptable risk value do not require beneficiation. The probability can exceed the acceptable risk value for certain properties for two reasons: (1) the fly ash may have poor quality in general and thus requires beneficiation or (2) the historical information is not accurate and there are multiple strata within the stratum being tested (i.e., the assumption of homogenous stratum is false; this will increase the standard deviation of the properties and thus the probability of not meeting the ASTM limits). For each property with a probability value higher than the acceptable risk limit, data from the individual samples must be compared. If certain samples have values significantly different from the other samples, then reason (2) is more likely. However, if all samples are equally poor in quality, then reason (1) is more likely. In cases where the likely reason cannot be qualitatively established or when reason (2) is likely, sampling according to Method B must be performed.

Sampling Method A can also be used as an initial feasibility study. If the fly ash from the landfill/impoundment fails to meet the specification limits for several properties or if it is determined that the cost of beneficiation will be prohibitively high, then investing in the more rigorous sampling Method B can be avoided.

Method B: Regular Grid-Based Sampling

This method makes a conservative assumption that the landfill/impoundment is stratified, but the strata boundaries are unknown. It discretizes the landfill/impoundment horizontally into four grid blocks and vertically into 1.5 m deep segments, and samples each segment to capture the variability within the landfill/impoundment. Subsequently, it determines the necessary fly ash beneficiations for each segment. The way that landfills/impoundments are built (layer-by-layer or stockpiling materials in cells) ensures that the maximum heterogeneity will be across the depth.

Step B.1: In the plan view of the landfill (Figure 42 (b)) a 2×2 grid pattern is created such that the length and width of the landfill is divided into equal parts. Within each grid block, (a minimum of) 4 points are chosen such that they are as far as possible from each other and from the edges of the grid block. As such, the total number of points in the plan view will be (minimum) 16.

Step B.2: A boring sample is collected from each of the (minimum) 16 points in Step B.1 to sample the entire depth of the landfill. At every (maximum) 1.5 m, the boring is split to create separate segments. For example, if the landfill is 5 m deep at a given point, then 4 segments will be created: 0-1.5 m, 1.5-3 m, 3-4.5 m, and 4.5-5 m. The diameter of the boring must be large enough to obtain at least 2 kg of sample from each segment.

Step B.3: Each (minimum) 1.5 m deep segment within a grid block will be considered a homogeneous space. Each such space must be tested following steps A.3 and A.4 of Method A but using four segment samples instead of six. The necessary beneficiations for each homogeneous space are determined accordingly. If the four samples within any homogeneous space have significantly different values when compared to each other, then stratification within the homogeneous space is possible. Such instances are to be noted and handled during the quality control sampling.

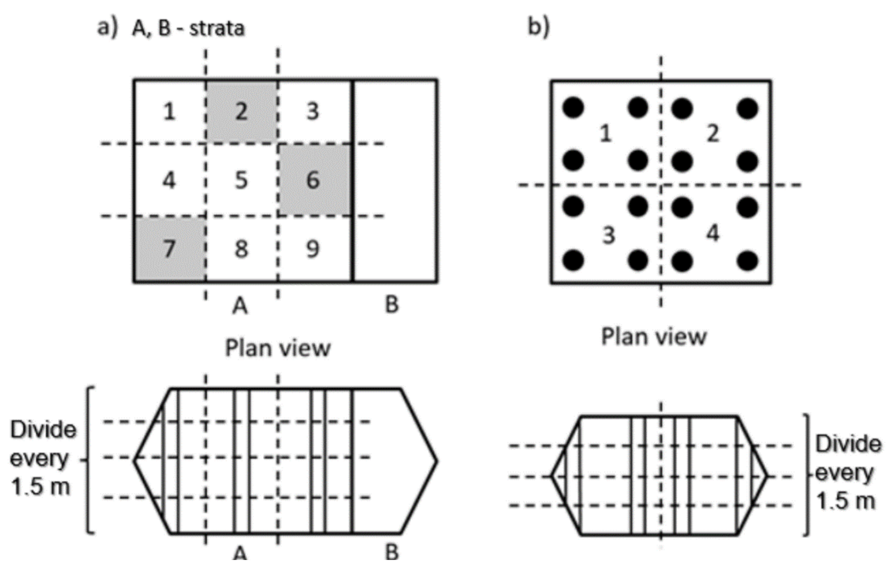


Figure 42: Schematic diagram for the initial sampling of a fly ash landfill with the location of boreholes shown a) stratified random sampling (Method A), and b) regular grid-based sampling (Method B)

Quality Control Exploration

Initial exploration is not sufficient to handle localized heterogeneities that may be present within a landfill/impoundment. To make sure that fly ash with consistent quality and reliability is produced from the landfill/impoundment, quality control sampling is needed during the excavation process. The quality control sampling should comply with the requirements of ASTM C311/C311M.

An example of fly ash sampling from a landfill in Pennsylvania is provided in the study by Kaladharan et al. (2019).

Appendix 13: Technology Readiness Level

The Technology Readiness Level (TRL) index is a globally accepted benchmarking tool for tracking progress and supporting development of a specific technology through the early stages of the innovation chain, from blue sky research (TRL 1) to actual system demonstration over the full range of expected conditions (TRL 9). There are various TRL rating scales that may be applicable to various technologies and, for the work related to this report, the Department of Energy Technology Readiness Level Scale (Table 14) is used and considered the most appropriate. A summary of TRL systems is shown in Figure 43 below (Ihara et al., 2018).

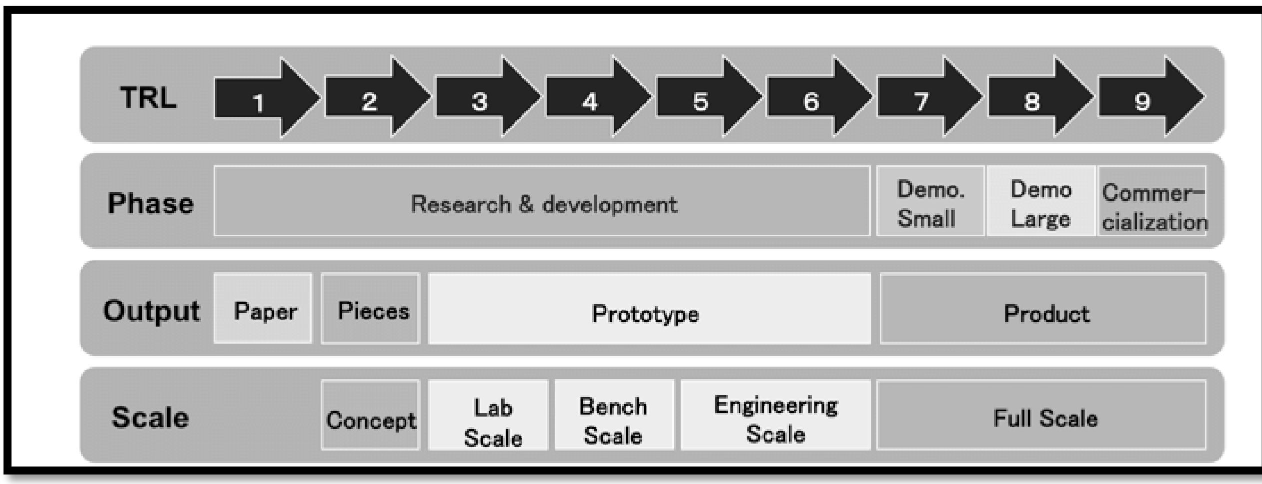


Figure 43: Department of Energy Technology Readiness Level Scale (US DOE, 2011)

Table 15: US Department of Energy Technology Readiness Level Guide

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
System Operations	**TRL 9**	Actual system operated over the full range of expected mission conditions.	The technology is in its final form and operated under the full range of operating mission conditions. Examples include using the actual system with the full range of wastes in hot operations.
System Commissioning	**TRL 8**	Actual system completed and qualified through test and demonstration.	The technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental testing and evaluation of the system with actual waste in hot commissioning. Supporting information includes operational procedures that are virtually complete. An Operational Readiness Review (ORR) has been successfully completed prior to the start of hot testing.
	TRL 7	Full-scale, similar (prototypical) system demonstrated in relevant environment	This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing full-scale prototype in the field with a range of simulants in cold commissioning[1]. Supporting information includes results from the full-scale testing and analysis of the differences between the test environment, and analysis of what the experimental results mean for the eventual operating system/environment. Final design is virtually complete.
Technology Demonstration	**TRL 6**	Engineering/pilot-scale, similar (prototypical) system validation in relevant environment	Engineering-scale models or prototypes are tested in a relevant environment. This represents a major step up in a technology's demonstrated readiness. Examples include testing an engineering scale prototypical system with a range of simulants.[1] Supporting information includes results from the engineering scale testing and analysis of the differences between the engineering scale, prototypical system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. TRL 6 begins true engineering development of the technology as an operational system. The major difference between TRL 5 and 6 is the step up from laboratory scale to engineering scale and the determination of scaling factors that will enable design of the operating system. The prototype should be capable of performing all the functions that will be required of the operational system. The operating environment for the testing should closely represent the actual operating environment.

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
Technology Development	**TRL 5**	Laboratory scale, similar system validation in relevant environment	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity, laboratory scale system in a simulated environment with a range of simulants[1] and actual waste[2]. Supporting information includes results from the laboratory scale testing, analysis of the differences between the laboratory and eventual operating system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. The major difference between TRL 4 and 5 is the increase in the fidelity of the system and environment to the actual application. The system tested is almost prototypical.
Technology Development	**TRL 4**	Component and/or system validation in laboratory environment	The basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of ad hoc hardware in a laboratory and testing with a range of simulants and small scale tests on actual waste2. Supporting information includes the results of the integrated experiments and estimates of how the experimental components and experimental test results differ from the expected system performance goals. TRL 4-6 represent the bridge from scientific research to engineering. TRL 4 is the first step in determining whether the individual components will work together as a system. The laboratory system will probably be a mix of on hand equipment and a few special purpose components that may require special handling, calibration, or alignment to get them to function.
Research to Prove Feasibility	**TRL 3**	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development (R&D) is initiated. This includes analytical studies and laboratory-scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative tested with simulants.1 Supporting information includes results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. At TRL 3 the work has moved beyond the paper phase to experimental work that verifies that the concept works as expected on simulants. Components of the technology are validated, but there is no attempt to integrate the components into a complete system. Modeling and simulation may be used to complement physical experiments.
	TRL 2	Technology concept and/or application formulated	Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
			limited to analytic studies. Supporting information includes publications or other references that outline the application being considered and that provide analysis to support the concept. The step up from TRL 1 to TRL 2 moves the ideas from pure to applied research. Most of the work is analytical or paper studies with the emphasis on understanding science better. Experimental work is designed to corroborate the basic scientific observations made during TRL 1 work.
Basic Technology Research	**TRL 1**	Basic principles observed and reported	This is the lowest level of technology readiness. Scientific research begins to be translated into applied R&D. Examples might include paper studies of a technology's basic properties or experimental work that consists mainly of observations of the physical world. Supporting Information includes published research or other references that identify the principles that underlie the technology.

[1] Simulants should match relevant chemical and physical properties.

[2] Testing with as wide a range of actual waste as practicable and consistent with waste availability, safety, ALARA, cost and project risk is highly desirable.

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ASTM C110, Standard Test Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone, ASTM International, West Conshohocken, PA.

ASTM C114, Standard Test Methods for Chemical Analysis of Hydraulic Cement, ASTM International, West Conshohocken, PA.

ASTM C191, Standard Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle, ASTM International, West Conshohocken, PA.

ASTM C311/C311M, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for use in Portland-Cement Concrete, ASTM International, West Conshohocken, PA.

ASTM C400, Standard Test Methods for Quicklime and Hydrated Lime for Neutralization of Waste Acid, ASTM International, West Conshohocken, PA.

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Virginia Gob Pile Analysis,
Quantification and Volumetrics

November 30, 2022

Prepared for:
Virginia Department of Energy
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Big Stone Gap, 24219

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November 30, 2022

Will Clear
Deputy Director
Virginia Department of Energy
3405 Mountain Empire Rd
Big Stone Gap, 24219

RE: Virginia Gob Pile Analysis, Quantification and Volumetrics

Dear Will:

This report summarizes **Marshall Miller & Associates, Inc.**'s (***MM&A***) and the **Virginia Department of Energy**'s (***VA Energy***) collaborative analysis pertaining to the quantification and volumetric calculations for Gob piles location in the Commonwealth of Virginia. This effort was a desktop study, incorporating multiple data sources to verify the locations and approximate volumes of Gob piles. The MM&A and VA Energy project teams have conducted multiple digital meetings throughout the duration of the project to ensure consistency with regards to data sources and methodologies.

The report appendix includes critical deliverables, including

1. Maps depicting locations of analyzed gob piles (See *Appendix 2*)
2. Corresponding volumetric estimates in table form (See *Appendix 1*)

In summary, the MM&A and VA Energy teams confirmed the presence of 151 gob piles which total over 80-million cubic yards of material. We greatly appreciate the opportunity to provide you with our services. It has been a pleasure working with the VA Energy team. Should you have any questions regarding the project or this report, please do not hesitate to reach out to us.

Sincerely,
MARSHALL MILLER & ASSOCIATES, INC.

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/rgw
Attachments
File: Final Gob Report (VAEN100- 2022-11-30).docx

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TABLES (IN REPORT)

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1 Introduction

Virginia House Bill No. 657, enacted by the General Assembly of Virginia, states that:

"The Department of Energy (the Department), in cooperation with the public institutions of higher education serving the coalfield region of the Commonwealth, shall identify the approximate volume and number of waste coal piles present in the coalfield region of the Commonwealth and options for cleaning up such waste coal piles, including the use of waste coal in generation of electricity".

This project and report focus upon the first task mentioned above, namely the identification/quantification of waste coal (Gob) piles in Virginia and associated volumetric calculations. **Marshall Miller & Associates, Inc. (*MM&A*)** and the **Virginia Department of Energy (*VA Energy*)** collaborated to complete an initial desktop analysis focusing on the identification of Gob piles and the approximation of their volume. This project represents an initial step for the Commonwealth in ultimately mining and processing Gob piles for their use in electricity generation. Further follow-up studies are recommended to confirm this report's findings on those Gob piles with the highest recovery potential.

MM&A and VA Energy opted to divide the project into two separate geographic regions, with MM&A leading efforts on Gob piles in Buchanan, Russell and Tazewell Counties. The VA Energy team's work focused on Wise, Lee and Dickenson Counties.

In general, the term "*Gob Piles*" references predominately coarse (i.e., not impounded) material which was not processed or sold after mining. Historically, sizing based separations occurred proximal to mine portals. Material previously too small for consumption was discarded in Gob piles. Presently, such material has economic prospects, and consideration is being given to re-mining Gob piles as a cost-effective approach to generating power plant feedstocks. Additionally, the process has upside in reclaiming areas by cleaning up previously discarded material.

Traditional impoundments are generally not included in this desktop inventory and volumetric process. Impoundment construction and permitting is fairly well documented, and as such, represents much less of an unknown with regards to location and volumes in comparison to gob piles.

2 Project Team

Key project team members, including both representatives of MM&A and VA Energy, include:

Steve Keim, PE, PhD: Project manager and point of contact for MM&A. During his 10+ year tenure with MM&A, Steve has been involved with a multitude of coal-based projects, including reserve assessments, financial analysis, preparation plant studies, and mine planning. Directly applicable to this engagement is Steve's project background in cut/fill volumetric analysis in support of deriving surface mined tonnages for royalty reporting purposes. Steve is a registered member with the Society of Mining, Metallurgy & Exploration (*SME*). He is a registered Professional Engineer (*PE*) and holds Doctoral and Undergraduate degrees in Mining Engineering from Virginia Polytechnic Institute and State University (*Virginia Tech*). Steve has served the role of qualified/competent person on a multitude of mineral reserve reporting projects.

Setareh Afrouz, PhD: Project Engineer for MM&A, is a geotechnical engineer with a background in slope stability and geomechanical modeling. She holds a Doctorate degree from Virginia Tech. During her tenure at Virginia Tech, Dr. Alfrouz's responsibilities included instruction in many of the software packages utilized in this project, including various GIS and CAD platforms.

Chris Counts: GIS Analyst in the AML section of the VA Energy, has 20 years of GIS and Mapping experience in the oil and gas industry, including 12 years in consulting with MM&A and 8 years in the private sector with VirTex Eastern Producing.

Grace McCowan: AML GIS Specialist for the Virginia Department of Energy, has 6 months experience in abandoned mine land reclamation and 2 years of experience in Geographic Information Systems and Computer Aided Drafting.

Jesse Whitt: Mapping Inventory Manager for the AML section of the Virginia Department of Energy, has 13 years of experience in abandoned mine land reclamation and 18 years of experience in GIS and mapping.

Emily Williams: AMLER Project Specialist for the Virginia Department of Energy, has 6 months experience in abandoned mine land reclamation and GIS. She is currently studying geology and environment at East Tennessee State University with an anticipated graduation date of December 2022.

3 Data Sources

Multiple datasets were utilized to confirm the presence of Gob piles and calculate their volumes. These are summarized below.

3.1 Gob Piles Geodatabase

VA Energy provided MM&A with several Gob pile geodatabases, including the following:

- *"Gob Points"*, VA Energy's master database of all known Gob pile locations saved as points in shapefile format, assembled by VA Energy with attribute features inclusive of coordinates, data collection method (digitized or hand-drawn), approximate area in acres, reclamation status, and vegetation. This geodatabase includes 137 georeferenced points within MM&A's 3-county designated area.
- *"Gob Projects"*: Database of select Gob pile perimeters saved as polygons in shapefile (.shp) with attribute features comprising information about reclamation/re-mining, under assessment, or completed. The dataset is inclusive of coordinates, Gob pile names and the reclamation process (Cap/Graded, removal) and reclamation progression status. Within MM&A's three county area, this data includes twenty-eight (28) Gob piles with eleven (11) of them marked as completely removed. Three of the piles were flagged as being in process of removal. The remaining fourteen (14) were stated to be cap/graded.

3.2 Digital Elevations and Imagery Data

Three notable datasets were used and reviewed for this project to estimate the approximate boundaries and volumes of Gob piles. These datasets include:

- *USGS 1/3 arc-second Contours.* This data includes geospatial elevation contours derived from 1/3 arc-second 3D Elevation Program (3DEP) data [see Reference 1]. Elevation models depicting original (i.e., pre-Gob placement) were generated from this data.
- *USGS 3DEP* Elevation. This data includes geospatial high resolution Light Detection and Ranging (LiDAR) data referred to as National Elevation Dataset (*NED*) [See Reference 2]. Elevation models representing current surfaces (i.e., post-Gob placement) were generated from this data.
- *Satellite imagery in Google Earth* is reviewed for notable changes in topography or vegetation which may suggest the presence of Gob piles. Imagery time dating from 1986 to current is available via open-source software.

4 Methodology

4.1 Overview

The project was conducted by a combined team consisting of individuals from both MM&A and VA Energy. The MM&A team lead efforts in Gob pile identification and the associated volumetric estimations for Tazewell, Buchanan and Russell Counties. The VA Energy team's responsibilities were associated with Gob piles located in Wise, Dickenson and Lee Counties.

The teams met via digital meeting platforms multiple times throughout the project to ensure consistency with regards to data sources, data manipulation, and general processes employed to confirm the locations of Gob piles and approximate their volumes. As a checks and balances system, the teams independently calculated volumes for four (4) waste piles and compared findings. While the teams utilized different software packages and slightly different processes (additional information below), it was unanimously determined that the processes employed by the teams yielded results with comparable accuracy. The relative error associated with the calculations was introduced by factors associated with the accuracy of available data, not the methods used to process the data.

Additionally, following the completion of each teams' respective Gob pile identification and volumetric exercises, each team conducted an audit of the other's supporting work files. Audit methodology is inherently not as exhaustive as a full evaluation since it places some reliance upon the work of others. As such, MM&A retains full responsibility of its work completed in Buchanan, Russell and Tazwell Counties. Similarly, VA Energy retains full responsibility of its work associated with Wise, Lee and Dickenson Counties.

4.2 Identification and Volumetric Processes

The location of potential Gob piles was provided to MM&A by VA Energy via the databases described in the preceding report section. Of important note, the "*Gob Points*" database served as the primary source for vetting locations and calculating volumes of Gob piles. In select instances, the "*Gob Projects*" database suggested the presence of additional potential Gob piles not referenced in the *"Gob Points"* database. At the current time, the volumes of such Gob piles have not been calculated by MM&A. Generally, these appear to be impoundments which may not meet typical "Gob pile" definitions—additionally, these represent projects which have already been considered by the VA Energy and are assumed to have already been studied in detail. Several impoundments have been included by VA Energy in its analysis, including several impoundments within MM&A's 3-county area. Such instances are flagged in *Appendix 1* and are noted as being impoundments as opposed to Gob piles.

Prior to any delineation of boundaries or calculation of volumes, the provided Gob data points were investigated to determine if anomalous features suggesting Gob placement could be identified via aerial imagery or existing high resolution LiDAR topography. If identifiable, Gob piles are labeled as such, and their boundaries and volumes are estimated using the available data via the processes outlined below. The remaining points are labeled as "not identified". Further reconnaissance is recommended to confirm/dispute the presence and volumes of those features listed in the "not identified" category.

The volumes of Gob piles have been estimated based on approximate boundary (perimeter) and depth of Gob (thickness), both of which are unknown. MM&A developed a method using digital elevation and imagery data to approximate these two parameters. The boundaries of each Gob pile are estimated based on the *USGS 3DEP Elevation* contours and confirmed by satellite imagery. *USGS 1/3 arc-second Contours* are used to estimate the original surfaces, before Gob placement. The thickness of Gob is calculated based on the interpolated elevation deference between new surface (USGS 3DEP Elevation) and original surface (USGS Contours). User judgement was incorporated in the process, both for selecting the most appropriate interpolation method, the inclusion of 3-dimensional break lines, and modification of original contours within the delineated perimeter Gob piles to help estimate original surfaces.

Methodologies utilized by the VA Energy team were very similar to those employed by MM&A. The most notable difference is associated with the derivation of original surfaces. While MM&A relied upon original USGS contours, the VA Energy team utilized advanced algorithms to re-create original surfaces via "Natural Regrade" functions within CAD and/or GIS software packages. As previously noted, the MM&A and VA Energy teams mutually agreed that both the MM&A and VA Energy methods were suitable for the exercise, neither being any more or less accurate than the other.

MM&A supplemented its process by including 2-dimenionsal surface profiles across each identified Gob pile to help determine the aerial extents of potential Gob placement.

A detailed explanation of steps utilized by the teams is summarized below.

3. Import Gob Piles Geodatabase to ARC/Global Mapper
4. Assess USGS 3DEP Elevation in Global Mapper and determine a rectangular Area of Interest boundary (*AOI*) for each Gob pile point
5. Export AOI perimeter of the potential Gob pile in DWG format
6. Investigate the potential Gob pile in Google Earth Pro for time-lapsed satellite imagery
7. Export the "New Surface" contours from USGS 3DEP Elevation Model within the AOI in DWG format with 2-ft contour intervals
8. Download USGS 1/3 arc-second Contour topo data within each AOI boundary and export it as "Original Surface" in DWG format (these contours are in 40 ft intervals); Add required break lines if required to help delineate stream and ridge features. *Note—VA Energy process utilizes natural regrade functions to estimate original surfaces instead of utilizing USGS contours.*
9. Interpolate and create 3-dimensional TIN surfaces from the Original Surface contours and New Surface contours
10. Generate Cut and Fill contours comparing the two 3-dimensional TIN surfaces. *Note—VA Energy process does not employ cut/fill contours.*
11. Define Fill Boundaries for the Gob pile based on Cut and Fill contours, Identified "Pile" shape features on New Surface and aerial imagery.
12. Confirm the Gob pile boundary delineation with 2- dimensional cross sections using of current and original surfaces.
13. Calculate and export the fill volume within the selected boundary.

5 Accuracy, Sources of Error, and Relative Impact

The accuracy of results is directly related to source information obtained and processed by the project teams and time/budget constraints which limit the breadth of the processes employed to verify the data. In general, MM&A estimates that presented volumes are generally in the order of +/- 50% relative accuracy, with most of the error being associated with challenges related to projecting original surfaces prior to the placement of Gob material. In some instances, greater relative error is likely, especially for those piles difficult to identify.

MM&A identified eight (8) notable sources of error. Relative error was ranked on a one (1) to three (3) scale, with a rating of three (3) representing those sources of error with the largest impact on results. Further, MM&A outlined future mitigation strategies which are recommended to be employed in the future to help lower the relative error when refining results. The sources of error presented below are in order of most significant to least significant.

Table 5-1: Relative Error #1 - Detailed Original Topographic Surface Not Available

Number	Aspect	Impact	Future Mitigation Strategies	Current Error Rating
1	Original surface contours not available for generation of highly accurate 3-diminesional topographic model, requiring projection of original contours (note--multiple methods utilized by project team to project original surfaces)	Reduced accuracy of volumetric calculations.	Surface based drilling activities to delineate depth of Gob material and help estimate original surface profiles.	3

Table 5-2: Relative Error #2 - User Error in Defining Aerial Extents of Gob Piles via Desktop Analysis

Number	Aspect	Impact	Future Mitigation Strategies	Current Error Rating
2	Inherent error in defining estimated aerial extents of Gob piles; challenges in determining if portions or all anomalous topographic features represent Gob or burden material.	Reduced accuracy in volumetric calculations.	Field reconnaissance to attempt to glean actual extents of Gob; surface-based drilling activities to delineate aerial extents of Gob piles.	3

Table 5-3: Relative Error #3 - Inability to Confirm Presence of Various Gob Piles as Desktop Exercise

Number	Aspect	Impact	Control Measures	Current Error Rating
3	Identification of Gob piles not achievable as desktop exercise utilizing available data sources. Cannot identify anomalous topographic features and cannot identify presence of Gob pile via aerial imagery.	Presence of certain Gob piles not confirmed. In general, it is likely that such Gob piles are either absent or relatively small in volume with lower likelihood of project development.	Field reconnaissance to attempt to identify Gob piles.	2

Table 5-4: Relative Error #4 - Inability to Confirm Quality of Gob Material as Desktop Exercise

Number	Aspect	Impact	Control Measures	Current Error Rating
4	Gob quality parameters have not been assessed as part of the project. In some instances, gob piles may have been combusted/burned, removing their potential for power generation. Pertinent quality parameters which should be assessed prior to consideration for thermal market consumption include, but are not limited to: heating value, ash content, moisture content, sulfur content, and state of oxidation.	While gob volumes may appear sufficient for project development, poor quality characteristics could limit potential for marketability.	Field reconnaissance and drilling activities to confirm quality.	2

Table 5-5: Relative Error #5 - Assumption of all Material Representing Gob vs. Cap Thickness/Dilution Assumptions

Number	Aspect	Impact	Control Measures	Current Error Rating
5	Gob identification and volumetric assessment process assumes that all material between current surface and original estimated surface is Gob.	Cap thickness and/or any dilution in Gob pile will reduce Gob volumes in comparison to what is projected in this report.	Surface based drilling activities to confirm presence of Gob, dilution and cap thickness. Reconnaissance of available AML project records to determine cap thickness if available.	1

Table 5-6: Relative Error #6- Accuracy of Current Topographic Model

Number	Aspect	Impact	Control Measures	Current Error Rating
6	Current topographic model is dated ~10 years. inherent error exists with regards to vegetation.	Development activities proceeding topographic model reduce accuracy of calculations; presence of dense vegetation can skew contours.	Obtain recent flown topography prior to project consideration.	1

Table 5-7: Relative Error #7 - Reliance on Previous Unconfirmed Work Related to Gob Pile Delineation (a)

Number	Aspect	Impact	Control Measures	Current Error Rating
7	Databases with Gob pile locations relied upon without field reconnaissance.	Cannot confirm or dispute contents of piles--risk related to whether piles are truly Gob material or other material.	Field reconnaissance and drilling activities prior to project considerations.	1

Table 5-8: Relative Error #8 - Reliance on Previous Unconfirmed Work Related to Gob Pile Delineation (b)

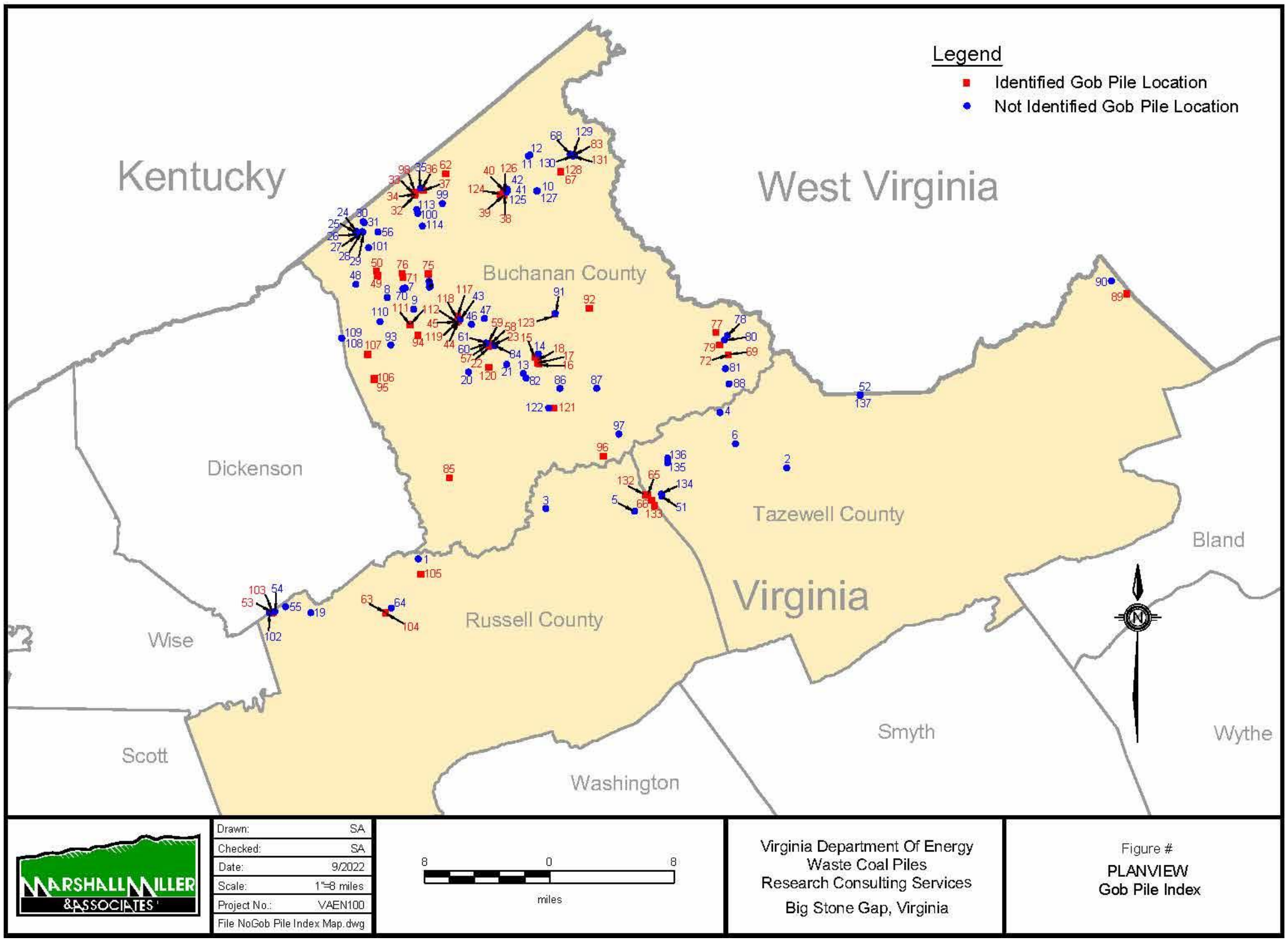
Number	Aspect	Impact	Control Measures	Current Error Rating
8	Databases with Gob pile locations relied upon.	Although provided databases appear robust and well developed, additional Gob piles may exist. If additional Gob piles exist, it is likely that they are relatively small and would not be favorable for project development.	Detailed field reconnaissance/public surveys to help locate additional Gob sites.	1

6 Results of Study

6.1 MM&A (Buchanan, Russell and Tazewell Counties)

MM&A investigated the 137 Gob Points to determine if they were identifiable. MM&A was able to identify and calculate volumes for 58 separate gob piles. Note that in some instances, separate gob points have been combined, as they effectively represent the same pile. In other instances, single gob points were subdivided into separate, independent piles for volumetric tabulations. A table containing results is included in the appendix. *Figure 6-1* includes a map depiction of the location of the Gob Points, including those which were identifiable by MM&A. These maps are also included in *Appendix 2*.

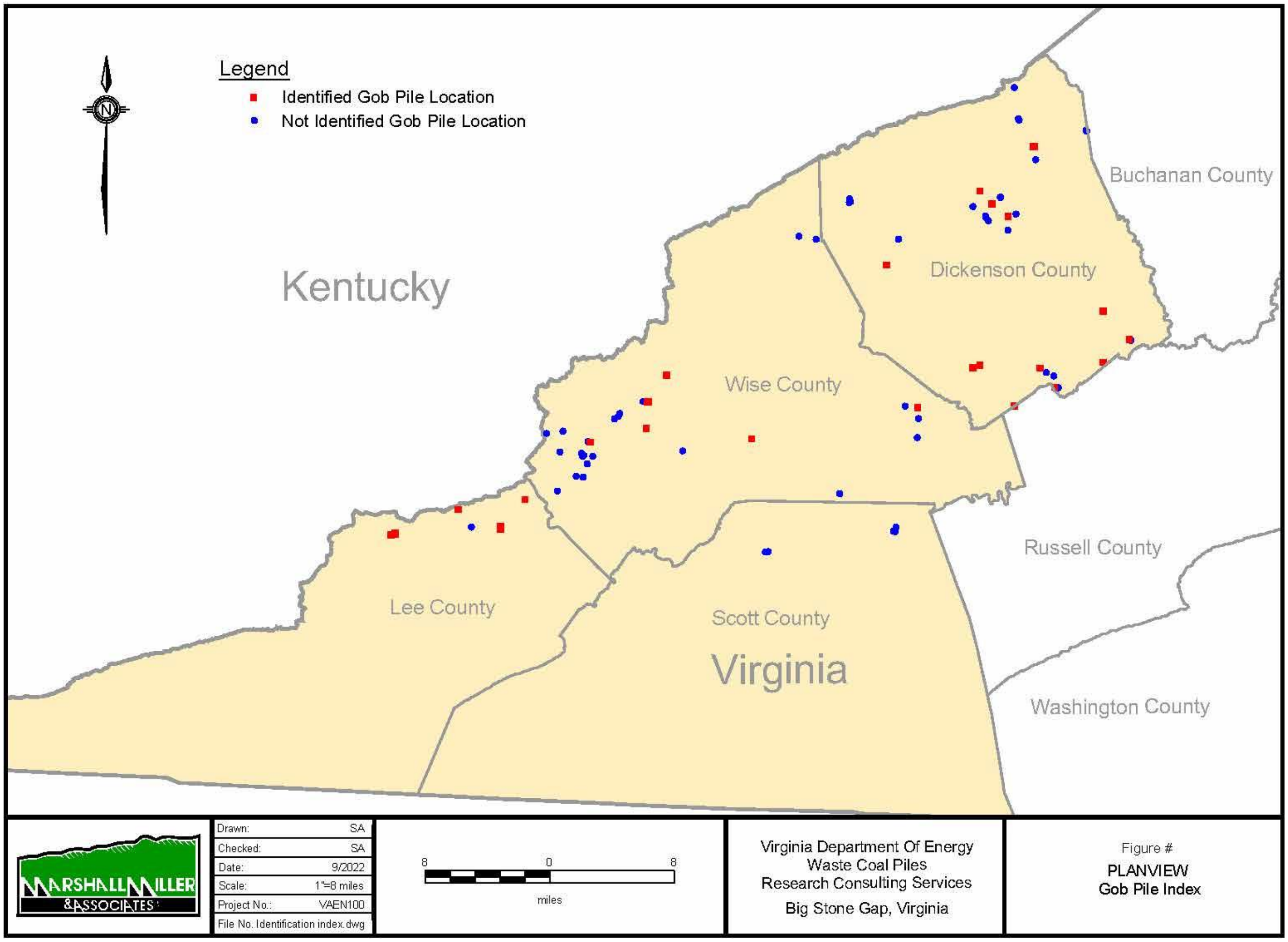
Figure 6-1: MM&A Planview Gob Pile Index



6.2 VA Energy (Wise, Dickenson and Lee Counties)

VA Energy investigated the 157 Gob Points to determine if they were identifiable. Of the 157 Gob Points, VA Energy was able to identify and calculate volumes for 93 Gob piles. Detailed results of volumetric estimates are included in the report appendix. The 93 piles identified by VA Energy in includes some material which may be categorized as Refuse Impoundments as opposed to typical coarse, gob material. Given the high level of the study, such data and results are included in totals.

Figure 6-2: VA Energy Planview Gob Pile Index



7 Audit of Work

7.1 MM&A Audit of VA Energy Work

MM&A conducted an audit level review of the work completed by VA Energy in Wise, Dickenson and Lee Counties. Data presented in the appendix, along with corresponding geodatabases was made available to MM&A. As audit methodology is not inherently as exhaustive as a full evaluation, VA Energy retains responsibility for the delineation and volumetric calculations for Gob piles located in its 3-county region. Significant findings of the audit include:

1. The VA Energy's team maintained a consistent approach with regards to methodology and documentation of work.

2. Data processing practices are largely in line with those utilized by MM&A. While VA Energy utilized a different approach to project original (pre-Gob placement) surface, the processes used by both MM&A and VA Energy are sufficient for this level of study.
3. On a test-case basis, MM&A found that VA Energy's volumes were approximately equivalent to those independently calculated by MM&A.
4. In summary, MM&A's audit confirms that volumes estimated by VA Energy are aligned with best practices given the availability of data and time constraints for the project. MM&A and VA Energy's work are completed to a very similar level of detail.

7.2 VA Energy Audit of MM&A Work

Please see letter in *Appendix 5* outlining VA Energy's audit findings of MM&A's work.

8 Description of Supporting Files

8.1 Appendix Data—MM&A Supporting Files

The report appendix includes the following supporting information related to MM&A's study.

1. Plan View Map for all Identified Gob Piles with Existing Lidar Contours
2. Plan View Map for all Identified Gob Piles with Original USGS Contours and Cut/Fill Contours
3. 2-Dimensional Surface Profiles Across All Identified Gob Piles

8.2 Appendix Data—VA Energy Supporting Files

The report appendix includes the following supporting information related to VA Energy's work and audited by MM&A

1. 3-Dimensional Renderings of Surfaces Before Gob Placement
2. 3-Dimensional Renderings of Surfaces After Gob Placement
3. Calculation Notes Outlining Process Employed for Each Gob Pile
4. Calculation Spreadsheets

8.3 Final Geodatabase

MM&A and VA Energy have combined delineated Gob pile perimeters and associated volumes into a geodatabase. This geodatabase will be made available for distribution to the public by the government agency.

8.4 Retained Files – MM&A

MM&A has retained detailed supporting files in its vault. These include 3-dimensional models and contours of original and current surfaces; supporting CAD files; intermediate databases; and work notes.

9 Recommendations

This project served as an initial desktop exercise to provide a first-pass verification of the existence of gob piles and quantify their volume. Further follow up work is recommended, including field reconnaissance, drilling, and sampling to confirm the presence, volume, and quality of the subject gob piles.

10 References

1. U.S. Geological Survey, 2017, USGS 1/3 arc-second Contour Downloadable Data Collection: USGS - National Geospatial Technical Operations Center (*NGTOC*). Accessed on August 10, 2022. https://www.sciencebase.gov/catalog/item/4f70ab22e4b058caae3f8deb
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APPENDIX

1

DETAILED VOLUMETRIC RESULTS OF IDENTIFIED GOB PILES

Table 1: Volumetric Estimate

ID	Repsnosible Party	County	Gob / Refuse Impoundment	Approximate Volume (cubic yards)
CBC_51622708	VA Energy	Wise	Gob Pile	14,000
CBC_517221258	VA Energy	Dickenson	Gob Pile	12,000
CBC_517221259	VA Energy	Dickenson	Gob Pile	3,000
CBC_51722100	VA Energy	Dickenson	Gob Pile	17,000
CBC_60922556	VA Energy	Tazewell	Gob Pile	1,000
CBC_62222319	VA Energy	Wise	Gob Pile	43,000
GEM_62922457	VA Energy	Russell	Gob Pile	177,000
CBC_70622602	VA Energy	Buchanan	Gob Pile	41,000
GEM_70622606	VA Energy	Buchanan	Gob Pile	38,000
GEM_70722505	VA Energy	Buchanan	Gob Pile	147,000
CBC_70722532	VA Energy	Buchanan	Gob Pile	24,000
CBC_70822204	VA Energy	Dickenson	Gob Pile	593,000
GEM_71122329	VA Energy	Buchanan	Gob Pile	80,000
GEM_71122657	VA Energy	Buchanan	Gob Pile	44,000
GEM_71222204	VA Energy	Wise	Gob Pile	348,000
GEM_71222525	VA Energy	Tazewell	Gob Pile	249,000
GEM_71422814	VA Energy	Dickenson	Gob Pile	26,000
GEM_72122256	VA Energy	Lee	Refuse Impoundment	1,025,000
GEM_72122349	VA Energy	Wise	Refuse Impoundment	963,000
GEM_72122532	VA Energy	Wise	Refuse Impoundment	4,525,000
GEM_72122557	VA Energy	Wise	Refuse Impoundment	1,219,000
EBW_72122601	VA Energy	Buchanan	Refuse Impoundment	195,000
CBC_72122629	VA Energy	Wise	Refuse Impoundment	596,000
GEM_72122640	VA Energy	Buchanan	Refuse Impoundment	661,000
CBC_72122659	VA Energy	Russell	Refuse Impoundment	2,929,000
EBW_72122735	VA Energy	Buchanan	Refuse Impoundment	27,000
CBC_73122742	VA Energy	Buchanan	Refuse Impoundment	6,467,000
CBC_72122745	VA Energy	Buchanan	Refuse Impoundment	3,708,000
CBC_72122821	VA Energy	Buchanan	Refuse Impoundment	3,777,000
CBC_722221202	VA Energy	Buchanan	Refuse Impoundment	1,276,000
CBC_722221215	VA Energy	Buchanan	Refuse Impoundment	664,000
CBC_722221235	VA Energy	Buchanan	Refuse Impoundment	2,288,000
CBC_722221252	VA Energy	Buchanan	Refuse Impoundment	477,000
CBC_722221259	VA Energy	Buchanan	Refuse Impoundment	3,549,000
CBC_72222107	VA Energy	Buchanan	Refuse Impoundment	5,989,000
GEM_72222156	VA Energy	Russell	Refuse Impoundment	16,455,000
EBW_72722411	VA Energy	Lee	Gob Pile	24,000
GEM_72722430	VA Energy	Wise	Gob Pile	285,000
CBC_72722556	VA Energy	Dickenson	Gob Pile	7,000
CBC_72722608	VA Energy	Dickenson	Gob Pile	11,000
EBW_72722615	VA Energy	Lee	Gob Pile	91,000
EBW_72722628	VA Energy	Lee	Gob Pile	1,000
CBC_72722648	VA Energy	Dickenson	Gob Pile	27,000
CBC_72722650	VA Energy	Dickenson	Gob Pile	1,000
CBC_72722715	VA Energy	Dickenson	Gob Pile	261,000
CBC_72722812	VA Energy	Dickenson	Gob Pile	20,000
CBC_72922323	VA Energy	Dickenson	Refuse Impoundment	5,132,000
CBC_72922735	VA Energy	Dickenson	Gob Pile	8,000
CBC_72922747	VA Energy	Dickenson	Gob Pile	10,000
CBC_80122229	VA Energy	Dickenson	Refuse Impoundment	2,577,000
EBW_808221249A	VA Energy	Buchanan	Refuse Impoundment	44,000
EBW_81122349	VA Energy	Lee	Gob Pile	2,000
CBC_81222200	VA Energy	Lee	Gob Pile	45,000
CBC_81222257	VA Energy	Dickenson	Gob Pile	12,000

Table 1: Volumetric Estimate

ID	Repsnosible Party	County	Gob / Refuse Impoundment	Approximate Volume (cubic yards)
EBW_81522126	VA Energy	Lee	Gob Pile	18,000
EBW_81522541	VA Energy	Lee	Gob Pile	2,000
GEM_82422343	VA Energy	Russell	Gob Pile	137,000
CBC_825221207	VA Energy	Lee	Gob Pile	43,000
CBC_825221208	VA Energy	Wise	Gob Pile	4,000
CBC_825221209	VA Energy	Wise	Gob Pile	36,000
CBC_825221210	VA Energy	Wise	Gob Pile	3,000
CBC_825221211	VA Energy	Wise	Gob Pile	101,000
CBC_825221213	VA Energy	Wise	Refuse Impoundment	338,000
CBC_825221214	VA Energy	Wise	Gob Pile	65,000
CBC_825221221	VA Energy	Wise	Gob Pile	122,000
CBC_826221206	VA Energy	Wise	Gob Pile	794,000
GEM_82622643	VA Energy	Russell	Gob Pile	24,000
GEM_82922205	VA Energy	Russell	Gob Pile	171,000
GEM_82622713	VA Energy	Dickenson	Gob Pile	64,000
GEM_82622721	VA Energy	Russell	Gob Pile	157,000
CBC_82622828	VA Energy	Wise	Gob Pile	29,000
GEM_82922150	VA Energy	Dickenson	Gob Pile	121,000
GEM_82922152	VA Energy	Tazewell	Gob Pile	67,000
GEM_82922153	VA Energy	Buchanan	Gob Pile	3,000
CBC_83022145	VA Energy	Lee	Gob Pile	14,000
CBC_83022147	VA Energy	Lee	Gob Pile	11,000
CBC_83022148	VA Energy	Lee	Gob Pile	86,000
CBC_83022149	VA Energy	Lee	Gob Pile	54,000
GEM_83022559	VA Energy	Wise	Gob Pile	1,000
GEM_83022610	VA Energy	Wise	Gob Pile	98,000
GEM_83022611	VA Energy	Russell	Gob Pile	61,000
CBC_831221242	VA Energy	Tazewell	Gob Pile	63,000
CBC_831221243	VA Energy	Russell	Gob Pile	1,000
CBC_90222553	VA Energy	Buchanan	Gob Pile	515,000
CBC_919221031	VA Energy	Buchanan	Refuse Impoundment	666,000
EBW_71422229B	VA Energy	Buchanan	Gob Pile	3,000
EBW_71422229A	VA Energy	Buchanan	Gob Pile	198,000
CBC_71422146E	VA Energy	Buchanan	Gob Pile	10,000
CBC_71422146C	VA Energy	Buchanan	Gob Pile	25,000
CBC_71422146B	VA Energy	Buchanan	Gob Pile	106,000
CBC_71422146D	VA Energy	Buchanan	Gob Pile	92,000
CBC_71422146A	VA Energy	Buchanan	Gob Pile	472,000
EBW_808221249B	VA Energy	Buchanan	Refuse Impoundment	17,000
MMA_123	MM&A	Buchanan	Gob Pile	4,000
MMA_121	MM&A	Buchanan	Gob Pile	90,000
MMA_120	MM&A	Buchanan	Gob Pile	18,000
MMA_118/45	MM&A	Buchanan	Gob Pile	60,000
MMA_119	MM&A	Buchanan	Gob Pile	9,000
MMA_44	MM&A	Buchanan	Gob Pile	11,000
MMA_117	MM&A	Buchanan	Gob Pile	70,000
MMA_111/112	MM&A	Buchanan	Gob Pile	120,000
MMA_107	MM&A	Buchanan	Gob Pile	3,000
MMA_105	MM&A	Russell	Gob Pile	130,000
MMA_96	MM&A	Buchanan	Gob Pile	3,000
MMA_95	MM&A	Buchanan	Gob Pile	20,000
MMA_106	MM&A	Buchanan	Gob Pile	10,000
MMA_94	MM&A	Buchanan	Gob Pile	150,000
MMA_92E	MM&A	Buchanan	Gob Pile	11,000

Table 1: Volumetric Estimate

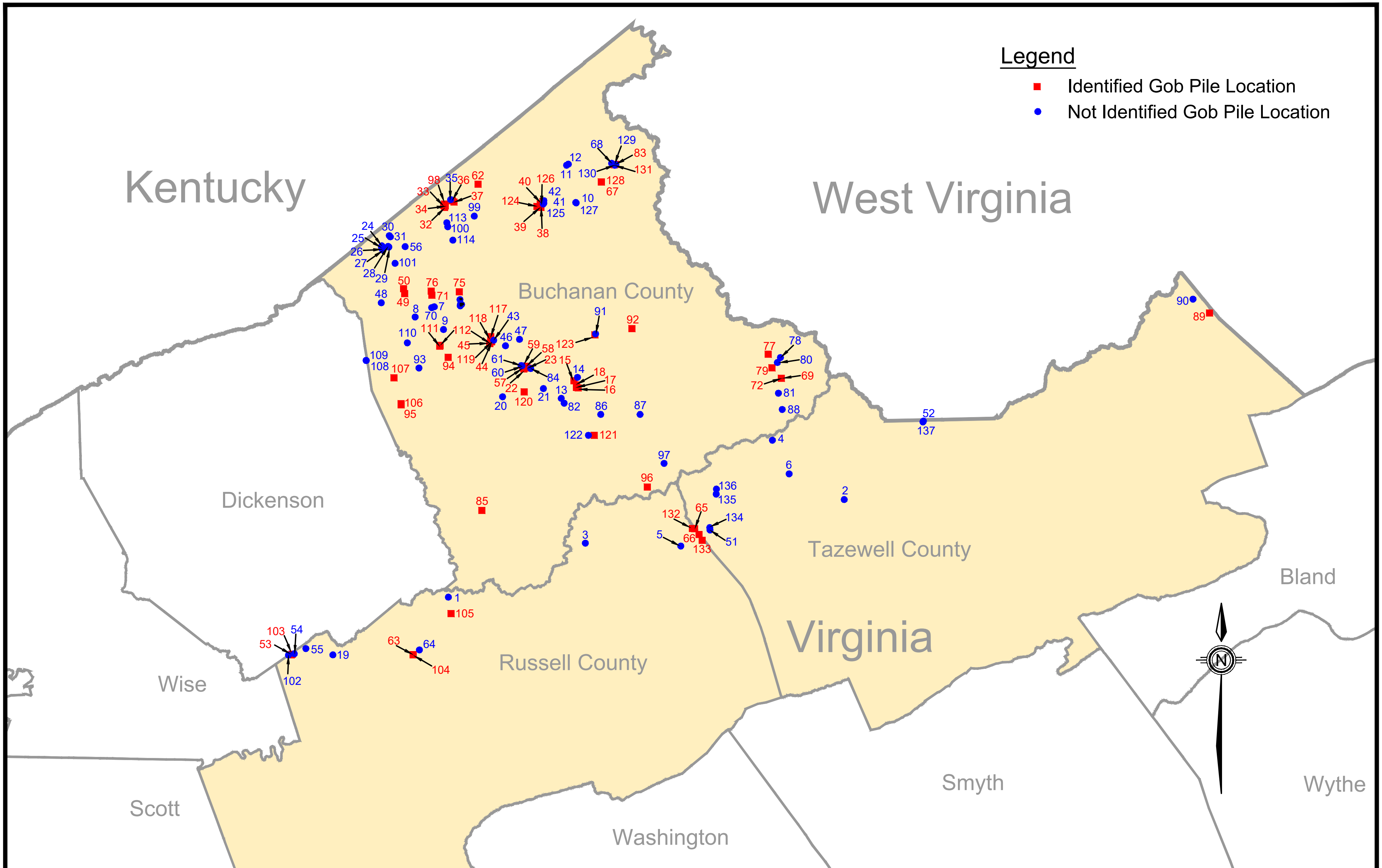
ID	Repsnosible Party	County	Gob / Refuse Impoundment	Approximate Volume (cubic yards)
MMA_92W	MM&A	Buchanan	Gob Pile	11,000
MMA_89	MM&A	Tazewell	Gob Pile	190,000
MMA_85	MM&A	Buchanan	Gob Pile	20,000
MMA_83	MM&A	Buchanan	Gob Pile	1,700
MMA_131	MM&A	Buchanan	Gob Pile	4,000
MMA_77	MM&A	Buchanan	Gob Pile	1,600
MMA_79	MM&A	Buchanan	Gob Pile	1,000
MMA_76	MM&A	Buchanan	Gob Pile	11,000
MMA_75E	MM&A	Buchanan	Gob Pile	300,000
MMA_75W	MM&A	Buchanan	Gob Pile	130,000
MMA_71N	MM&A	Buchanan	Gob Pile	3,000
MMA_71S	MM&A	Buchanan	Gob Pile	12,000
MMA_69/72	MM&A	Buchanan	Gob Pile	10,000
MMA_67/128	MM&A	Buchanan	Gob Pile	21,000
MMA_132	MM&A	Russell	Gob Pile	8,000
MMA_65N	MM&A	Russell	Gob Pile	40,000
MMA_65S	MM&A	Russell	Gob Pile	15,000
MMA_66N	MM&A	Russell	Gob Pile	19,000
MMA_66S	MM&A	Russell	Gob Pile	20,000
MMA_133	MM&A	Russell	Gob Pile	15,000
MMA_63/104	MM&A	Russell	Gob Pile	16,000
MMA_62	MM&A	Buchanan	Gob Pile	180,000
MMA_53	MM&A	Russell	Gob Pile	2,000
MMA_103	MM&A	Russell	Gob Pile	4,000
MMA_49	MM&A	Buchanan	Gob Pile	200,000
MMA_50	MM&A	Buchanan	Gob Pile	300,000
MMA_39	MM&A	Buchanan	Gob Pile	500,000
MMA_40/126	MM&A	Buchanan	Gob Pile	500,000
MMA_124	MM&A	Buchanan	Gob Pile	1,000,000
MMA_38	MM&A	Buchanan	Gob Pile	800,000
MMA_37	MM&A	Buchanan	Gob Pile	100,000
MMA_36	MM&A	Buchanan	Gob Pile	50,000
MMA_33/34	MM&A	Buchanan	Gob Pile	400,000
MMA_98	MM&A	Buchanan	Gob Pile	300,000
MMA_32	MM&A	Buchanan	Gob Pile	300,000
MMA_58	MM&A	Buchanan	Gob Pile	60,000
MMA_23	MM&A	Buchanan	Gob Pile	30,000
MMA_57	MM&A	Buchanan	Gob Pile	200,000
MMA_22	MM&A	Buchanan	Gob Pile	300,000
MMA_18	MM&A	Buchanan	Gob Pile	6,000
MMA_17	MM&A	Buchanan	Gob Pile	180,000
MMA_16	MM&A	Buchanan	Gob Pile	150,000
MMA_15	MM&A	Buchanan	Gob Pile	300,000

Total	**80,159,000**

Note: Approximate volumes, including total, are rounded as to not imply accuracy which exceeds the accuracy of the volume calculation process.
For complete discussion of inheretent error and accuracy of results, please see report Section 8.

APPENDIX 2

SUPPORTING MAPS DEPICTING LOCATIONS OF GOB PILES



MARSHALL MILLER &ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=8 miles
Project No.:	VAEN100
File NoGob Pile Index Map.dwg	

8 0 8
miles

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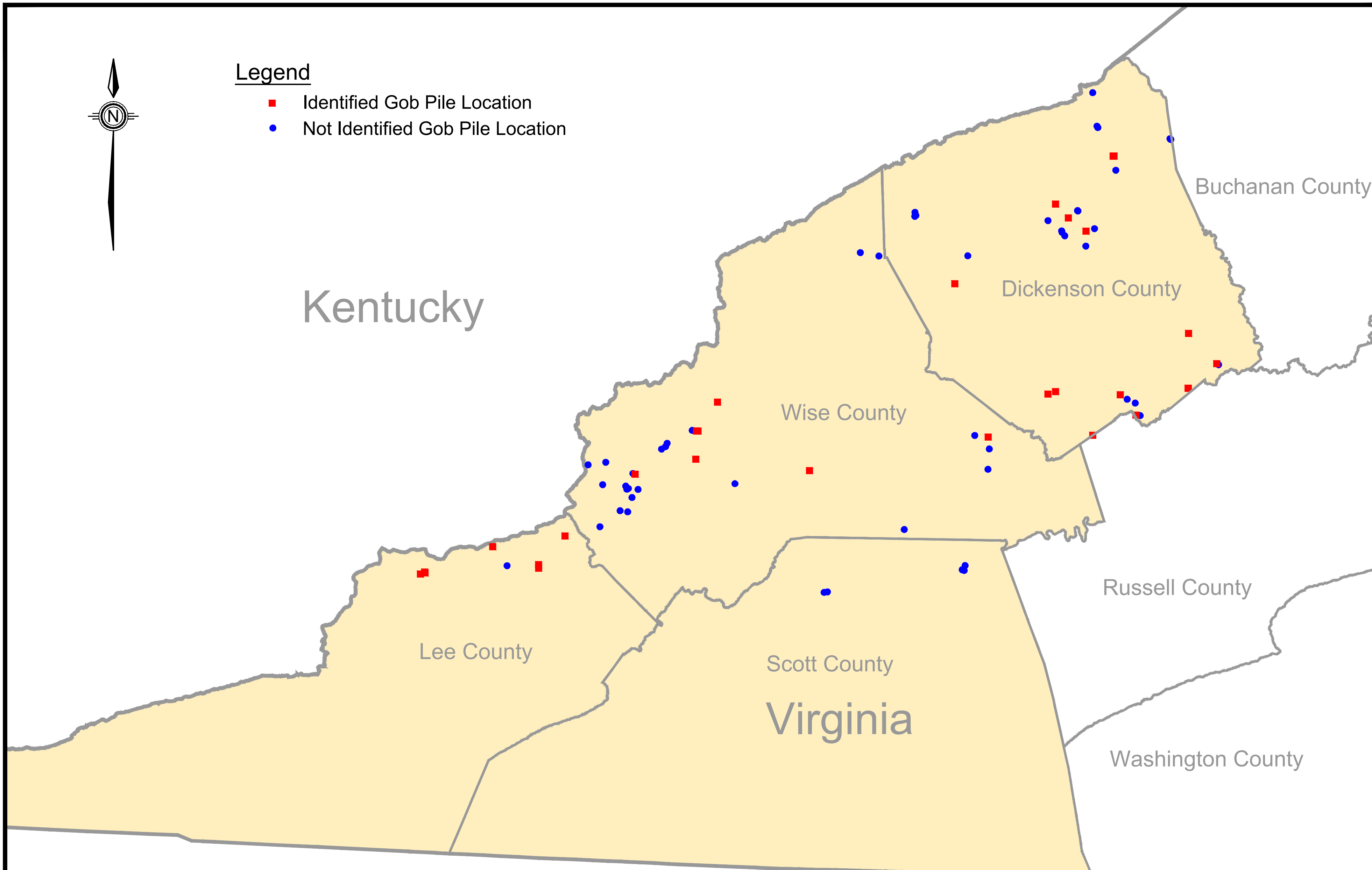
Big Stone Gap, Virginia

Figure # 1
PLANVIEW
Gob Pile Index



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Scale:	1"=8 miles
Project No.:	VAEN100
File No. Identification index.dwg	

8 0 8

miles

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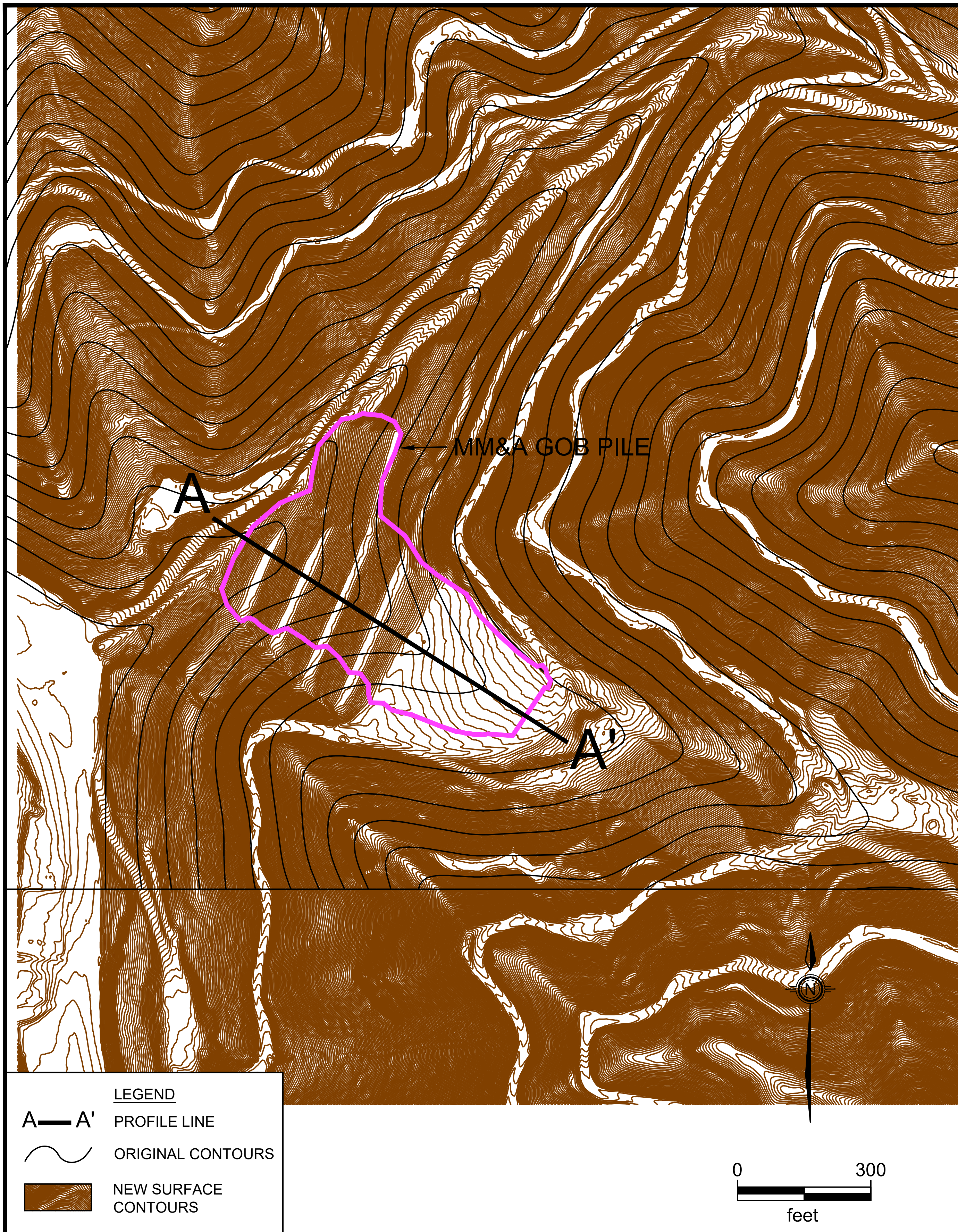
Figure #2

PLANVIEW
Gob Pile Index

APPENDIX

3

SUPPORTING INFORMATION, MM&A (BUCHANAN, TAZEWELL, RUSSELL COUNTIES)



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Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No. Oakwood Gob Pile.dwg	

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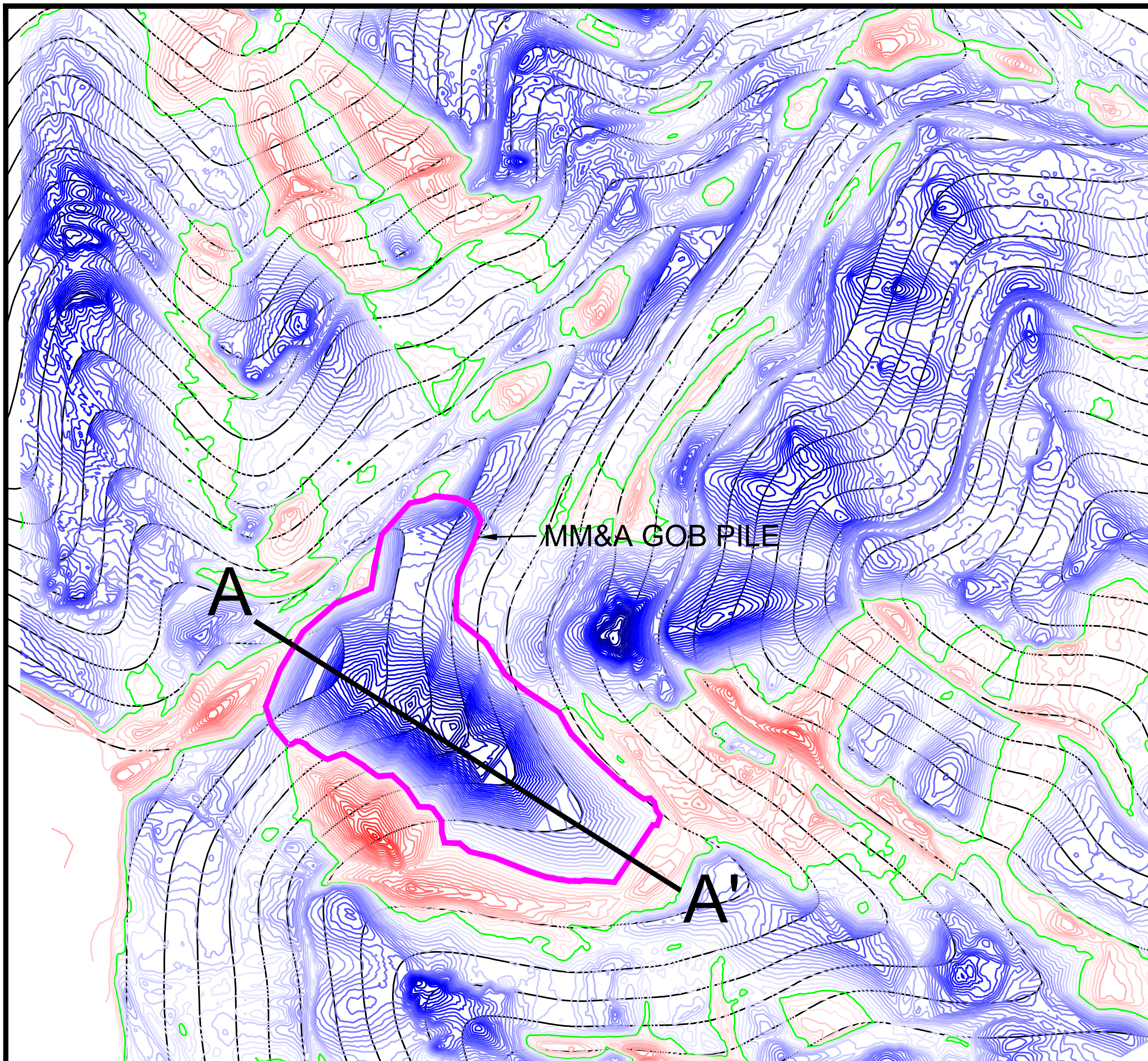
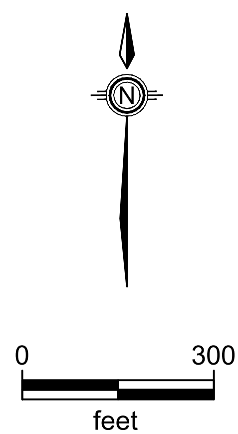
Exhibit 1A
PLANVIEW
OAKWOOD GOB PILES





LEGEND

A —— A' PROFILE LINE

ORIGINAL CONTOURS

FILL CONTOURS

CUT CONTOURS

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	15 CF.dwg

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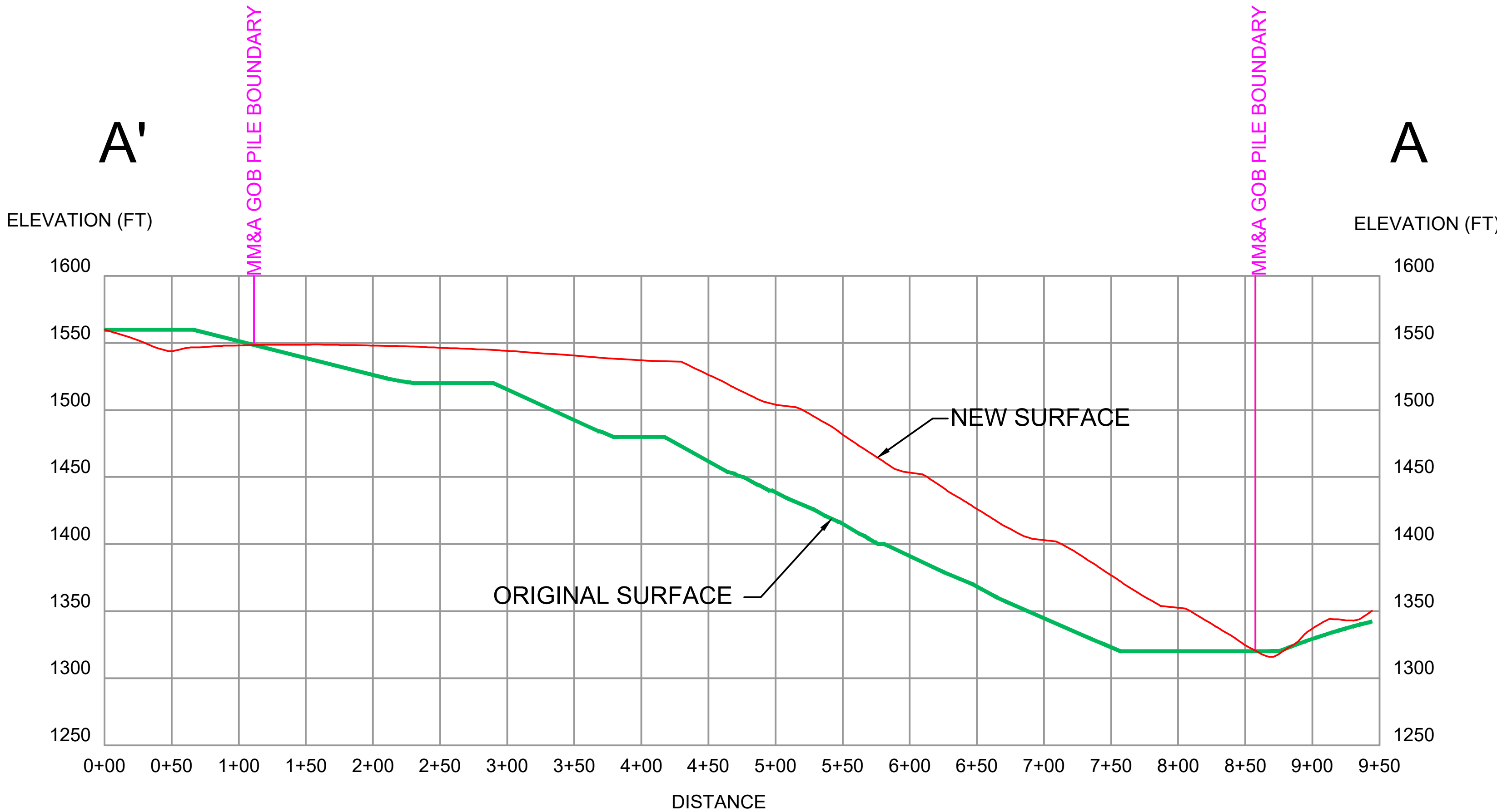
Big Stone Gap, Virginia

Exhibit 1B
PLANVIEW
GOB PILES 15



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	15 CF.dwg

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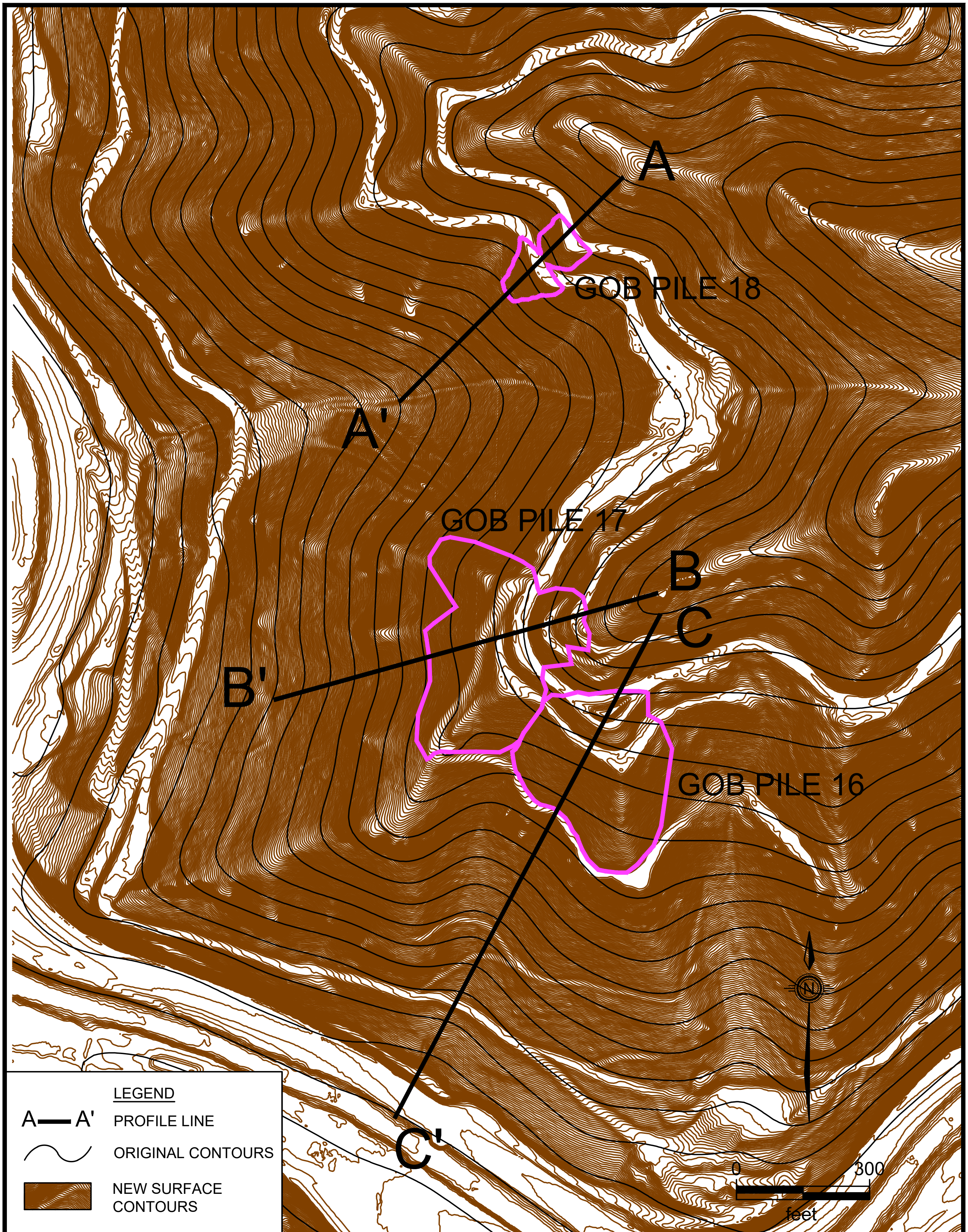
Exhibit 1C

GOB PILE 15
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	16-17-18 CF.DWG

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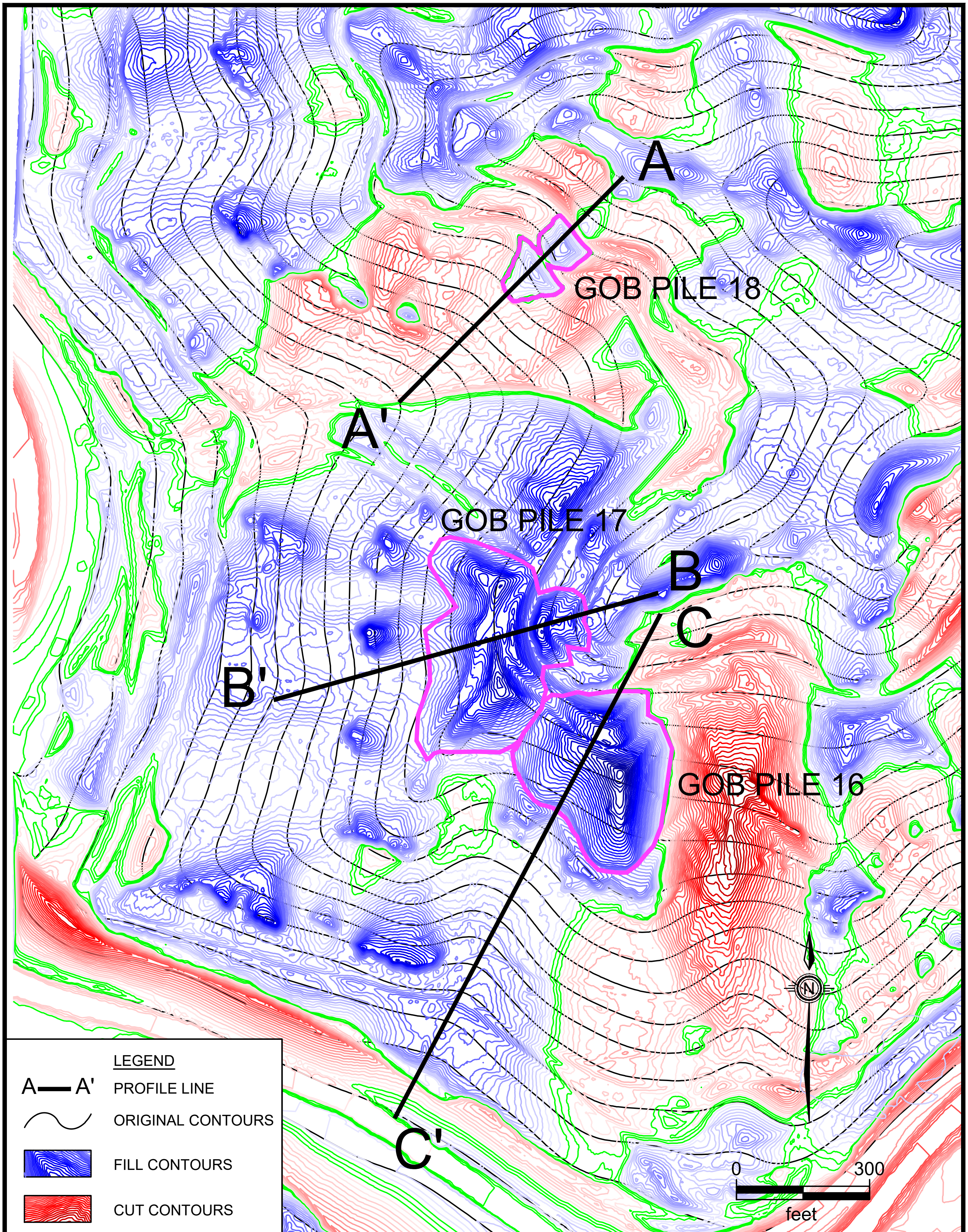
Big Stone Gap, Virginia

Exhibit 2A
PLANVIEW
GOB PILES 16, 17 AND 18



MARSHALL MILLER & ASSOCIATES ©

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	16-17-18 CF.DWG

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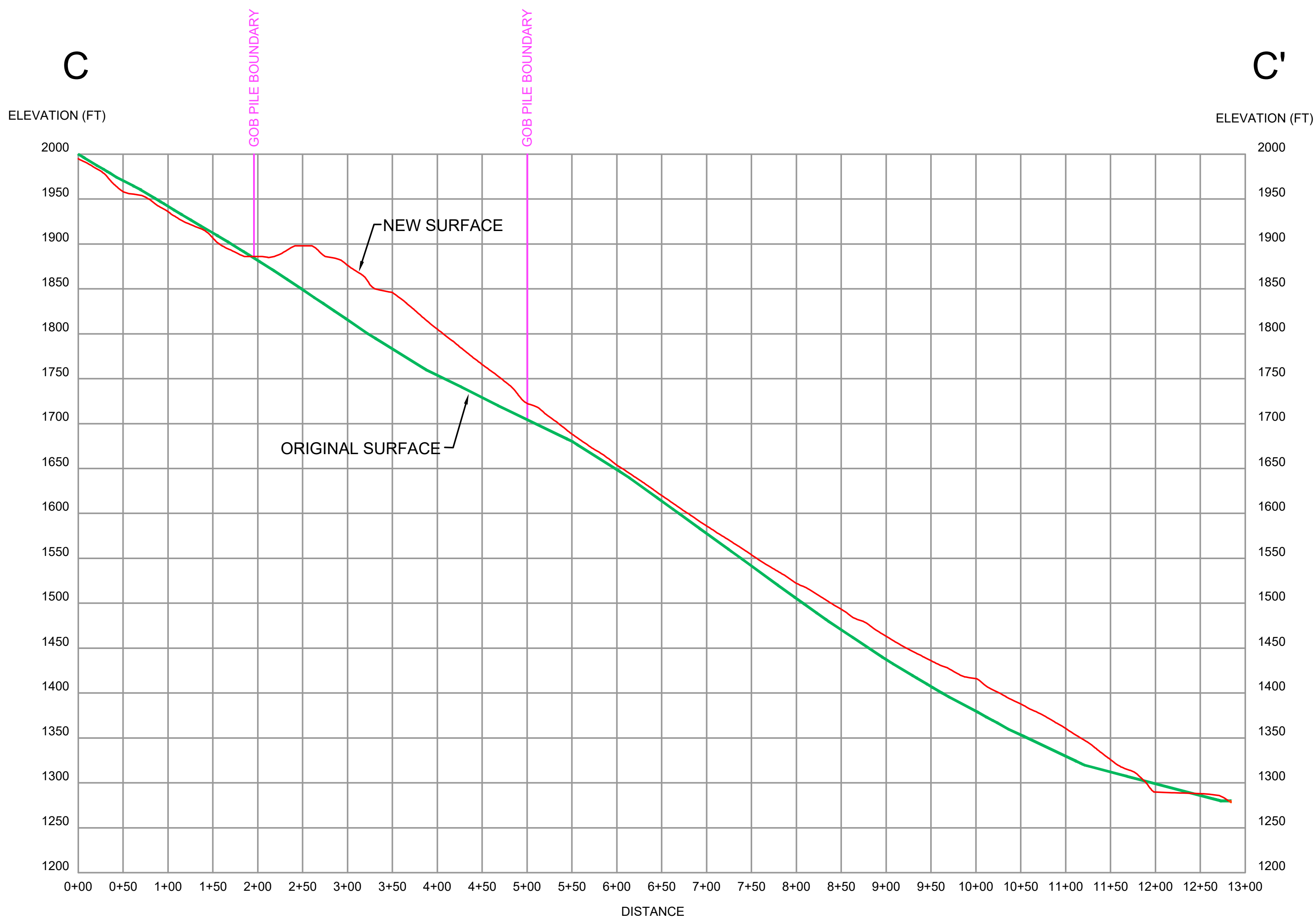
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 2B
PLANVIEW
GOB PILES 16, 17 AND 18



MARSHALL MILLER & ASSOCIATES

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Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	16-17-18 CF.DWG

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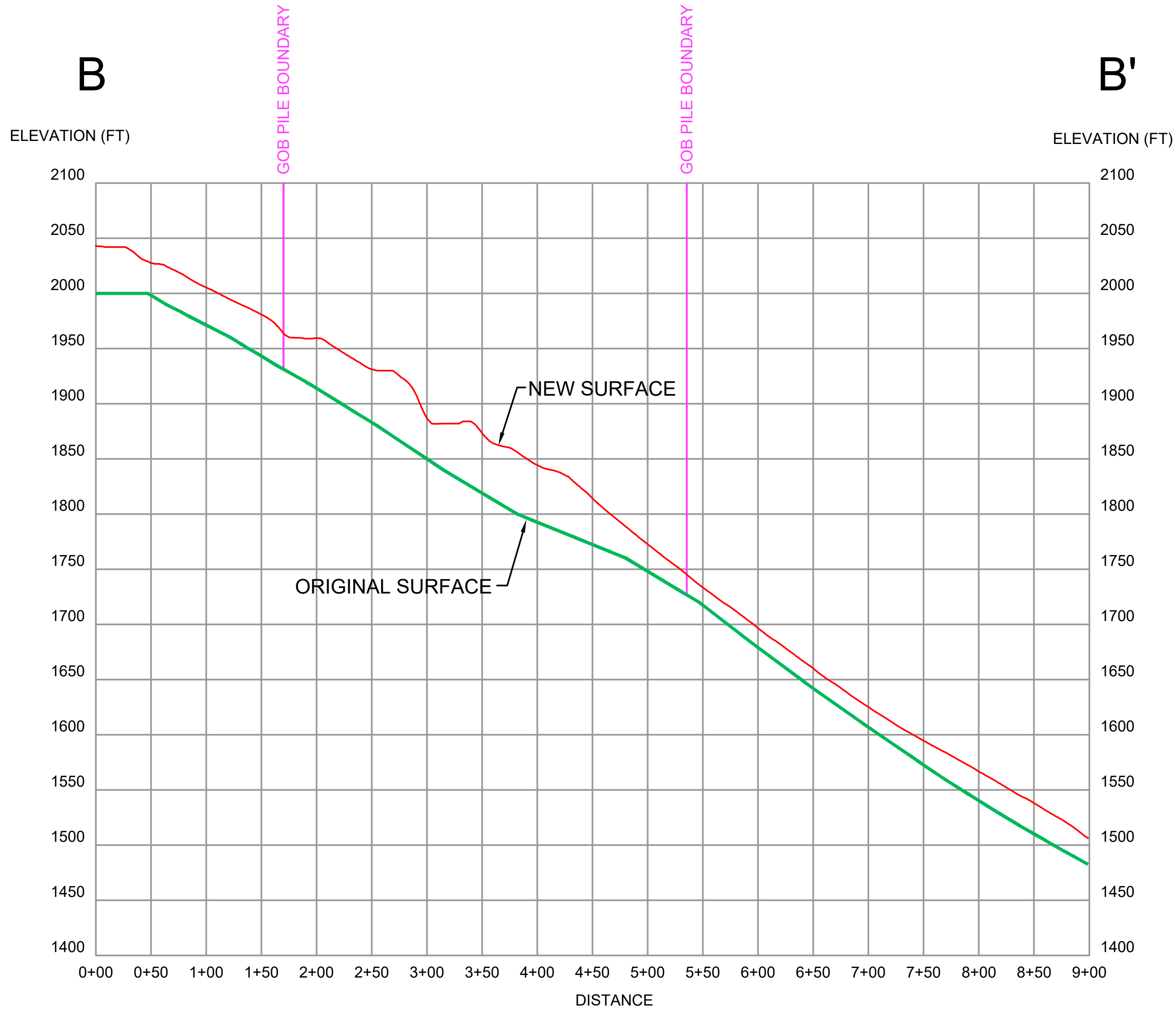
Big Stone Gap, Virginia

Exhibit 2C

GOB PILE 16
PROFILE C - C'



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Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	16-17-18 CF.DWG

Virginia Department Of Energy
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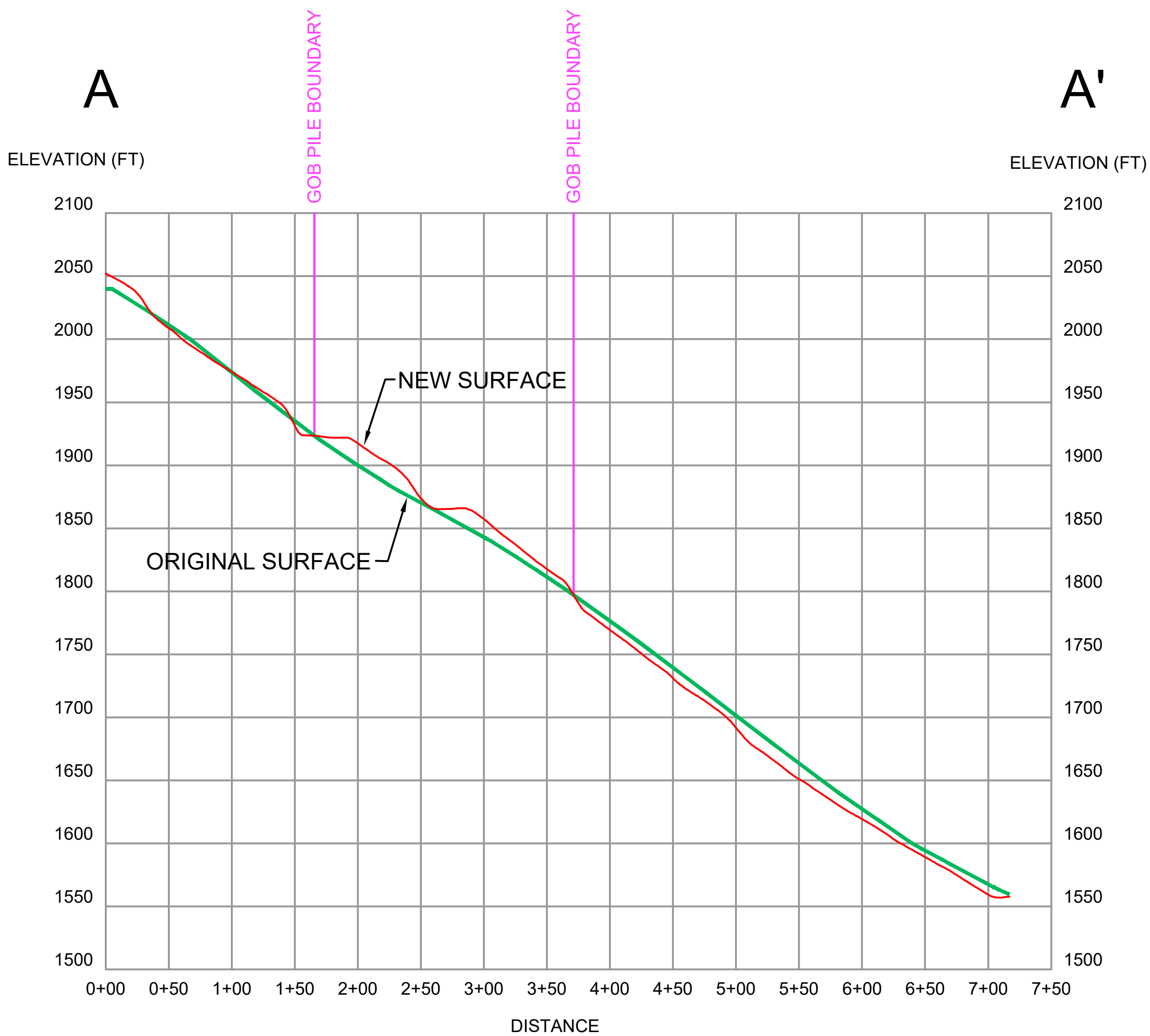
Exhibit 2D

GOB PILE 17
PROFILE B - B'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	16-17-18 CF.DWG

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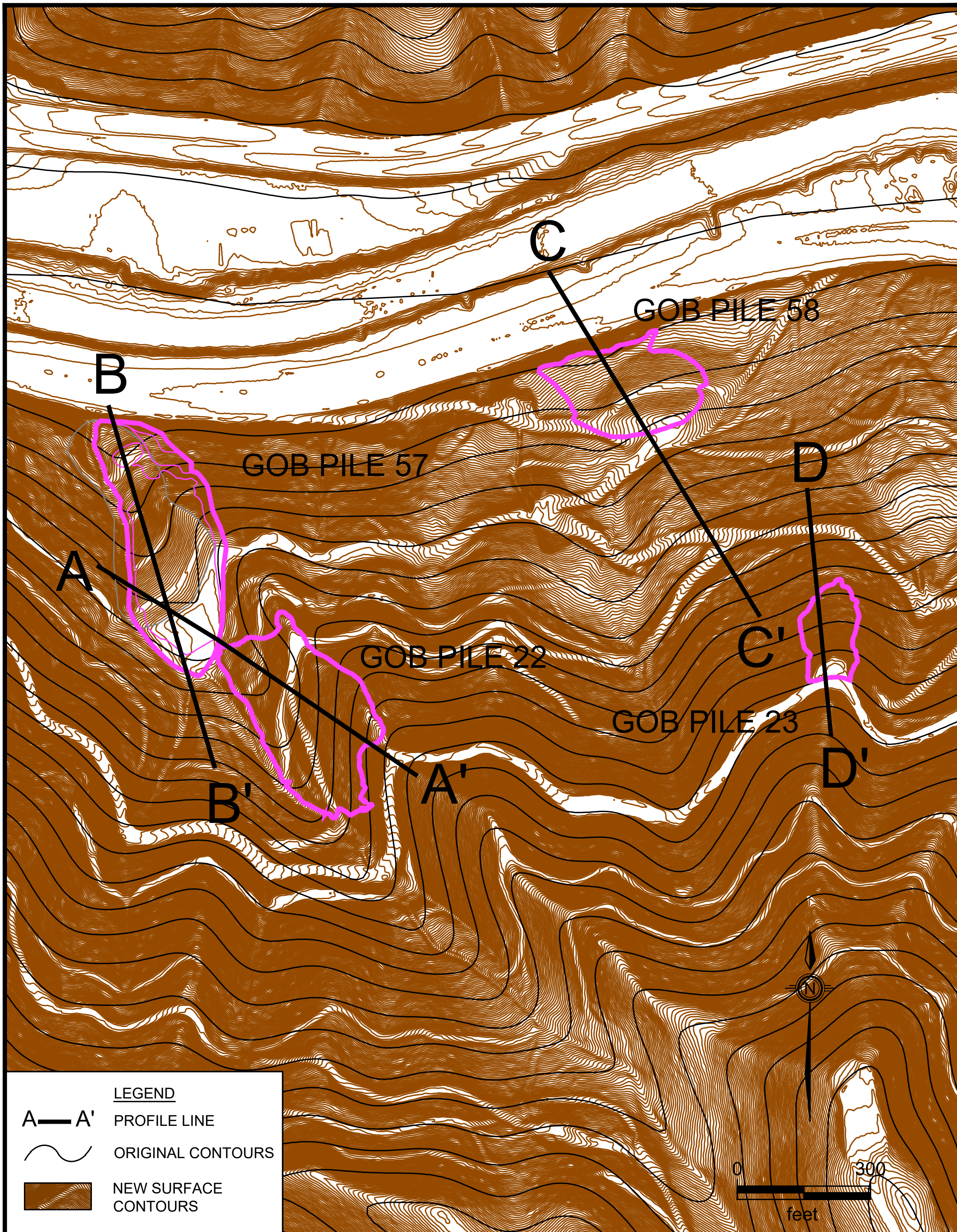
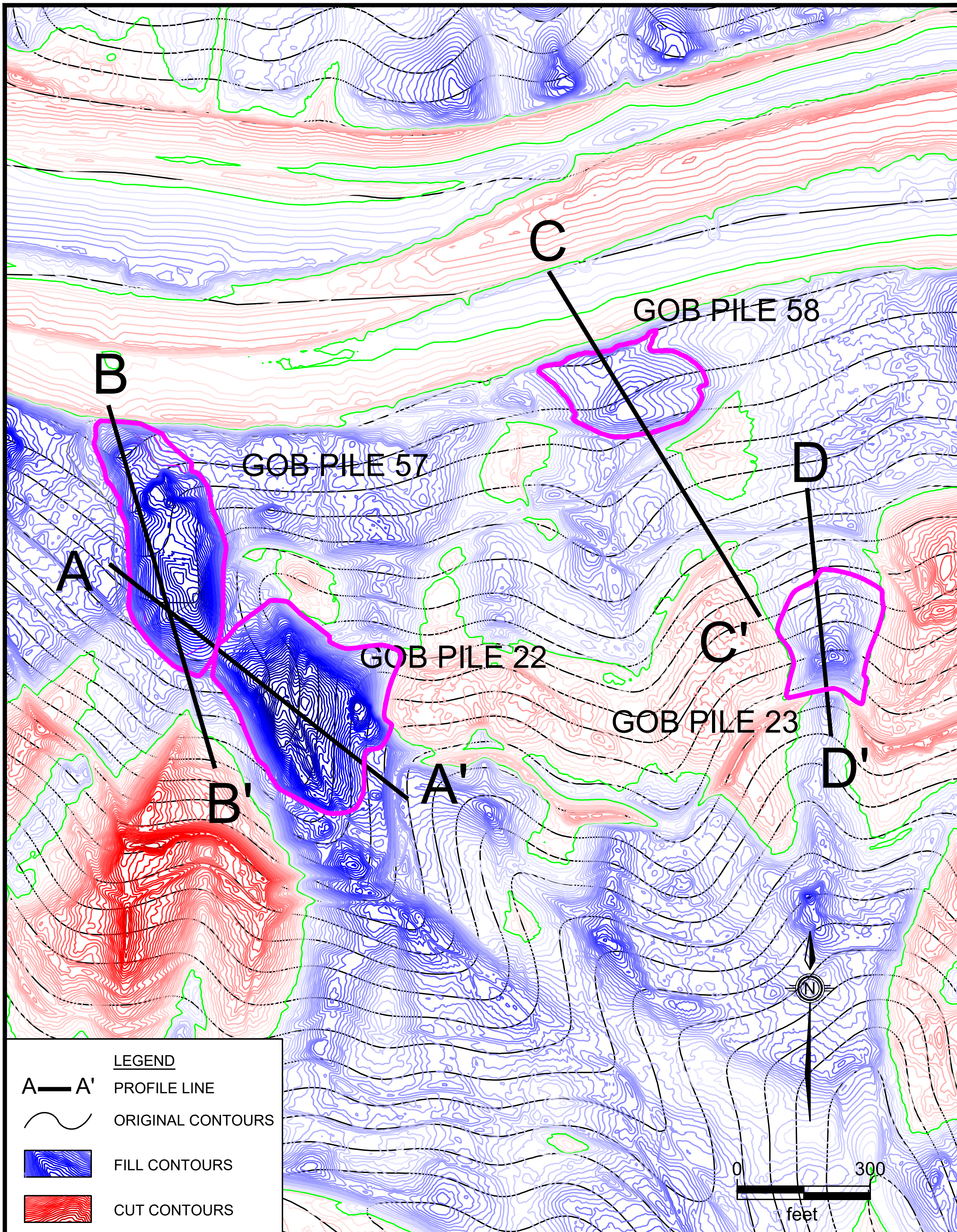
Exhibit 2E

GOB PILE 18
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES	Drawn: SA Checked: SA Date: 9/2022 Scale: 1"=300' Project No.: VAEN100 File No. 22-23-57-58 CF.DWG	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 3A PLANVIEW GOB PILES 22, 23, 57 AND 58



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Project No.:	VAEN100
File No.	22-23-57-58 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
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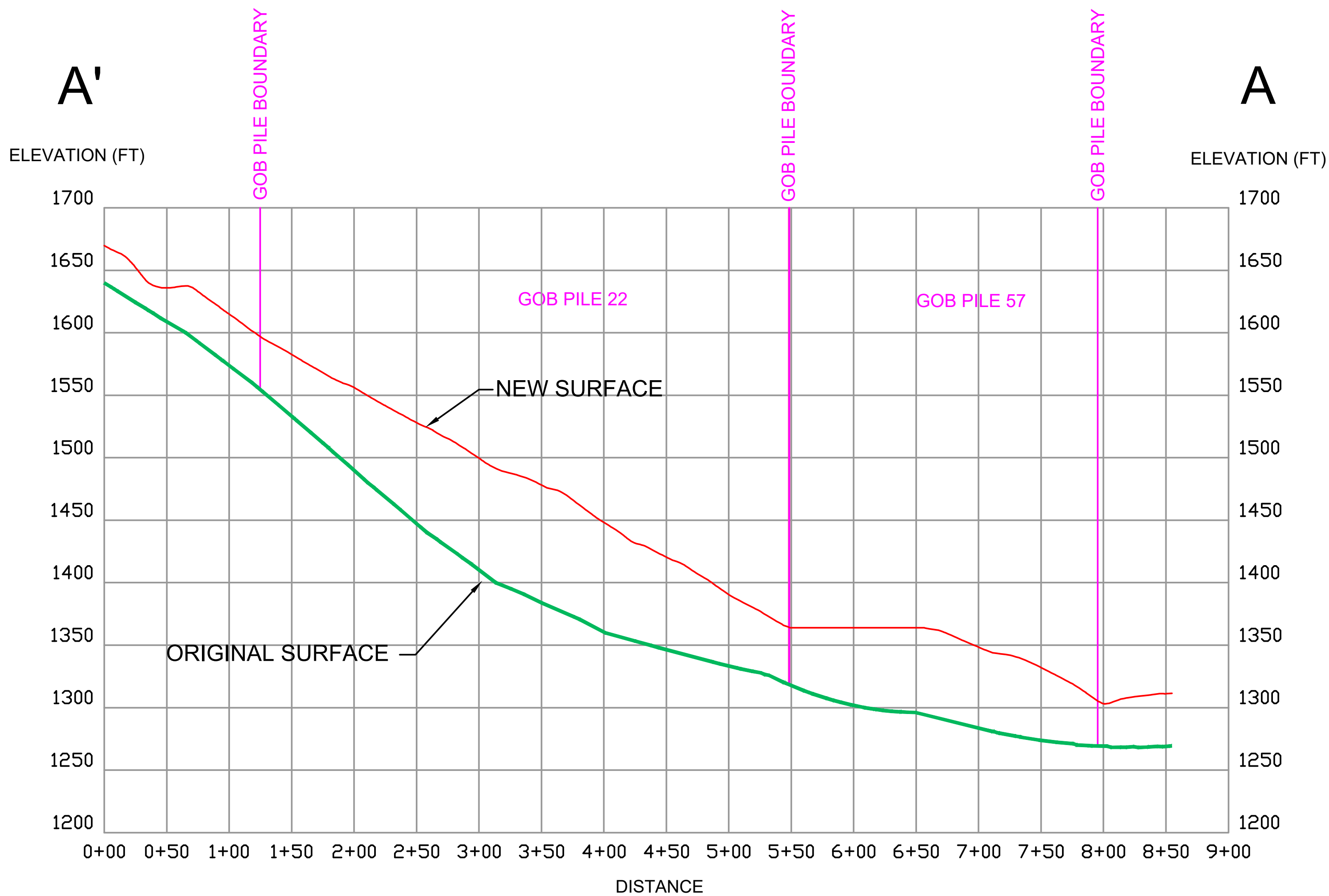
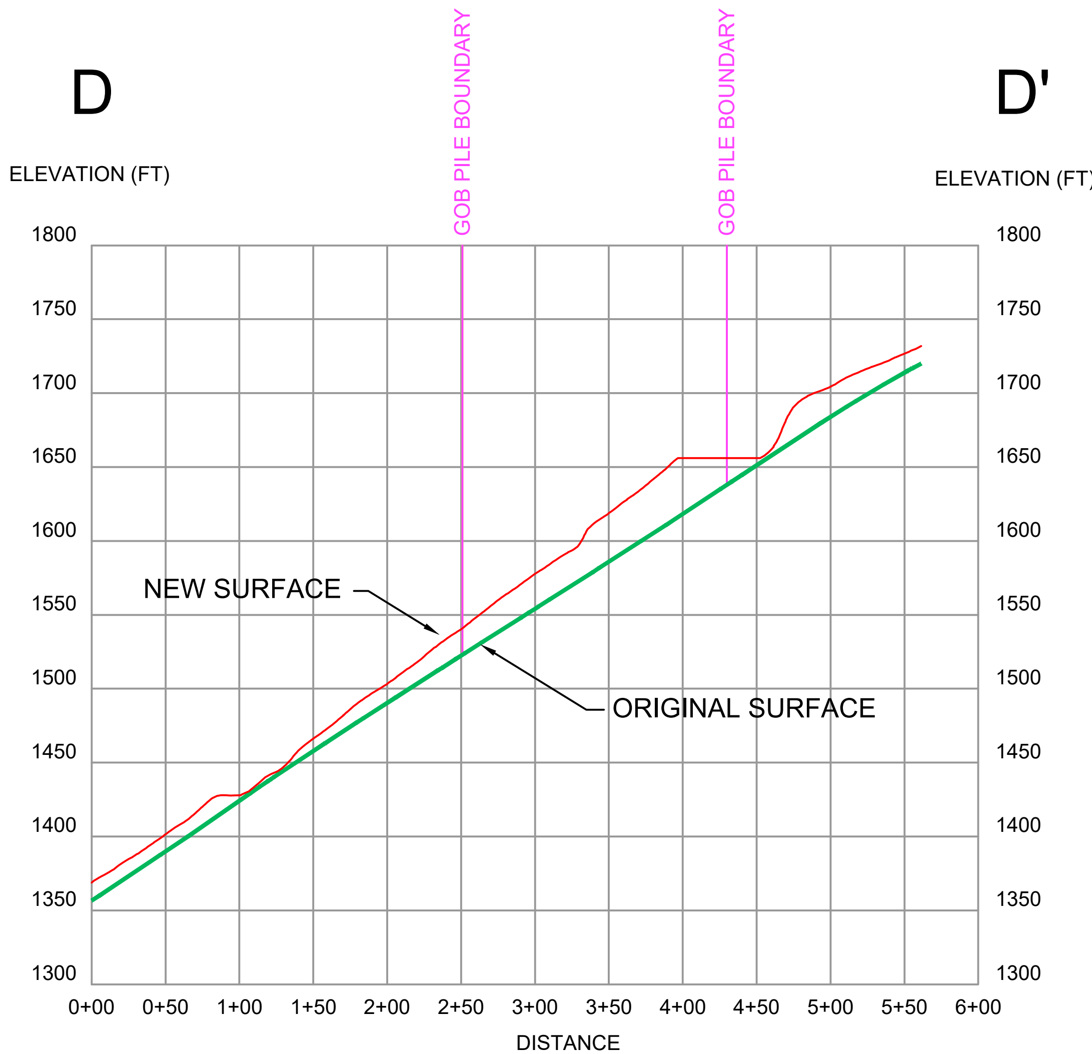
Big Stone Gap, Virginia

Exhibit 3B
PLANVIEW
GOB PILES 22, 23, 57 AND 58



MARSHALL MILLER & ASSOCIATES®	Drawn: SA Checked: SA Date: 9/2022 Scale: AS SHOWN Project No.: VAEN100 File No. 22-23-57-58 CF.DWG	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 3C GOB PILE 22 AND 57 PROFILE A - A'



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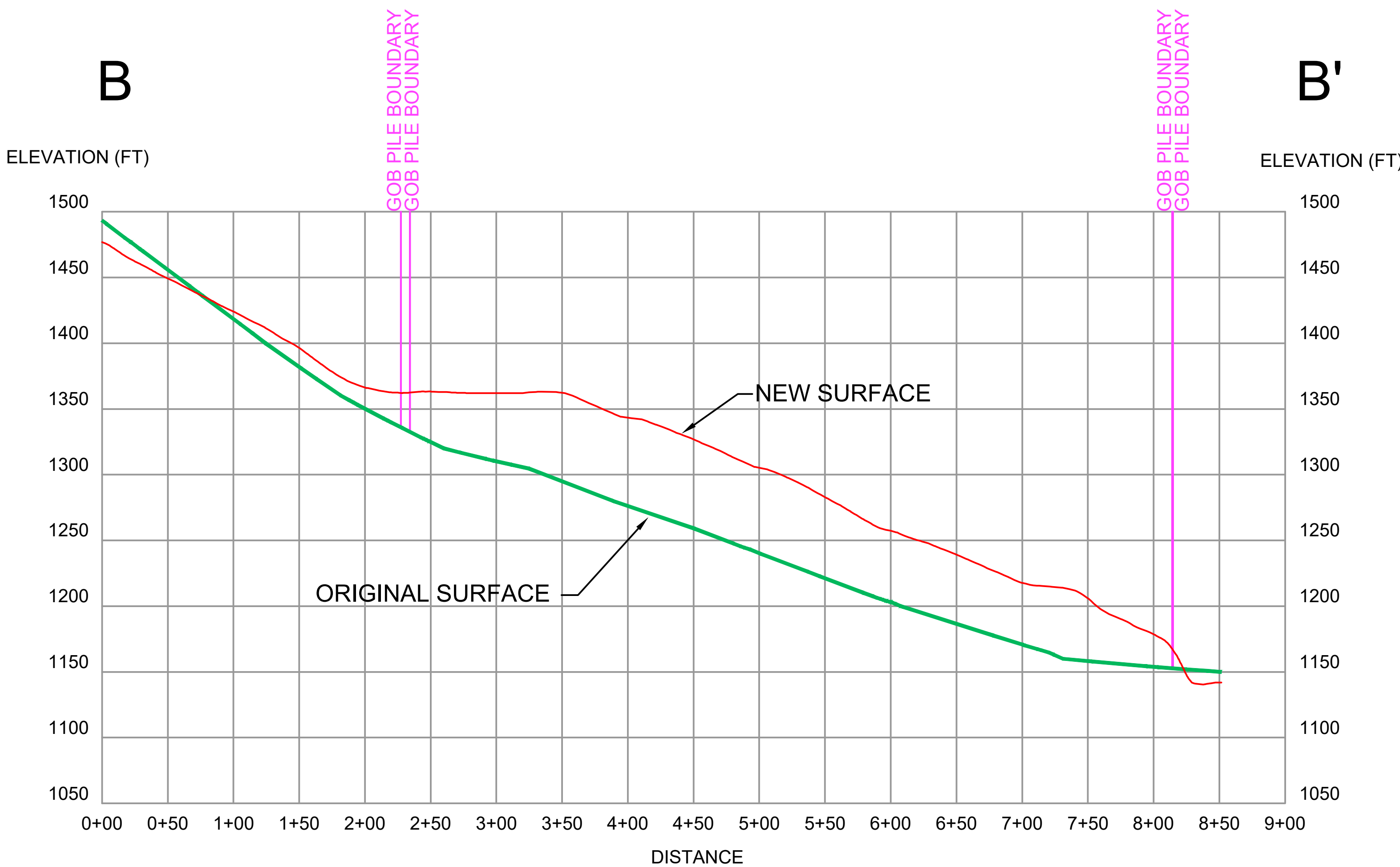
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	22-23-57-58 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 3D

GOB PILE 23
PROFILE D - D'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
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Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	22-23-57-58 CF.DWG

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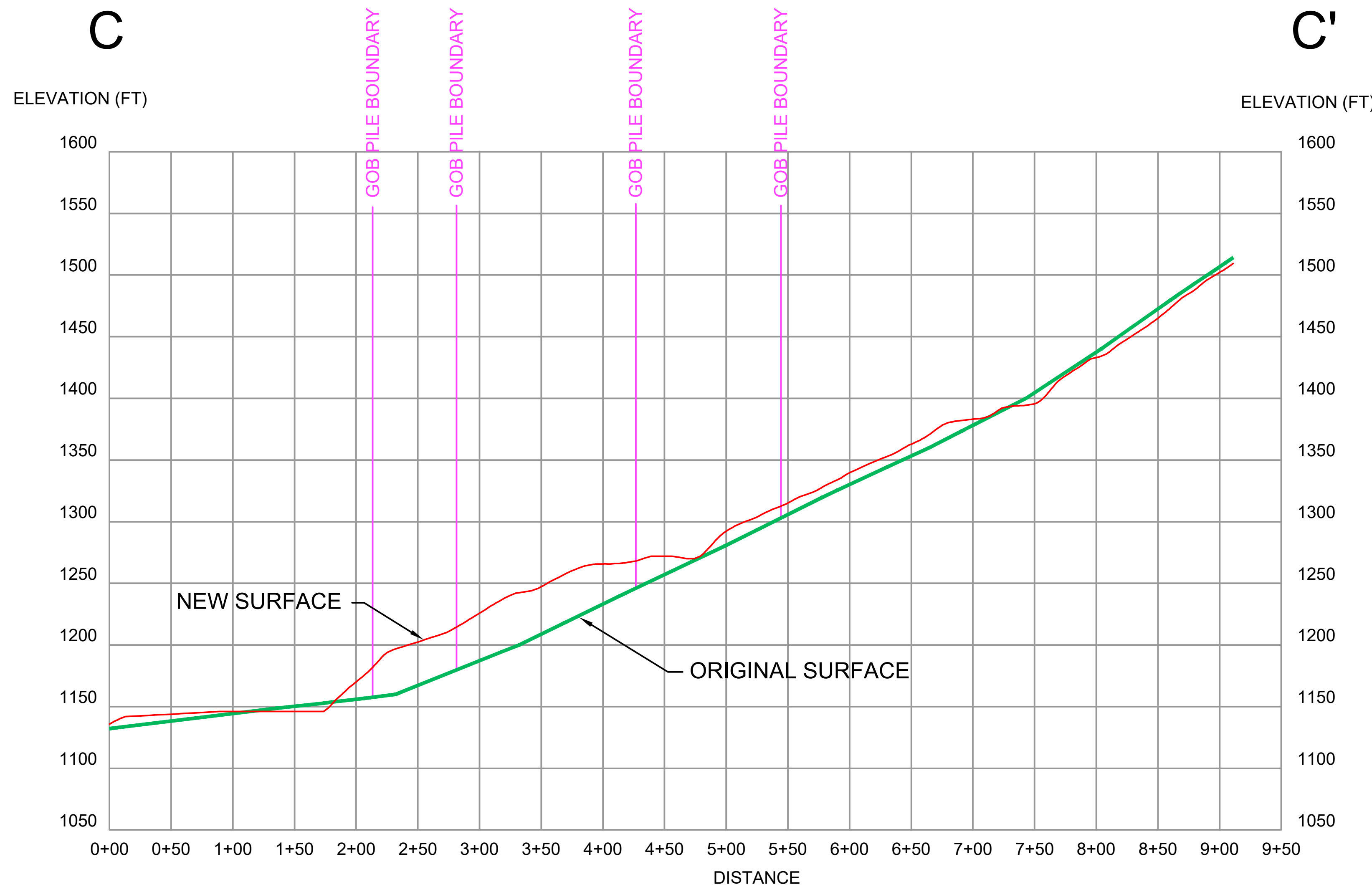
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 3E

GOB PILE 57
PROFILE B - B'



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Drawn:	SA
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Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	22-23-57-58 CF.DWG

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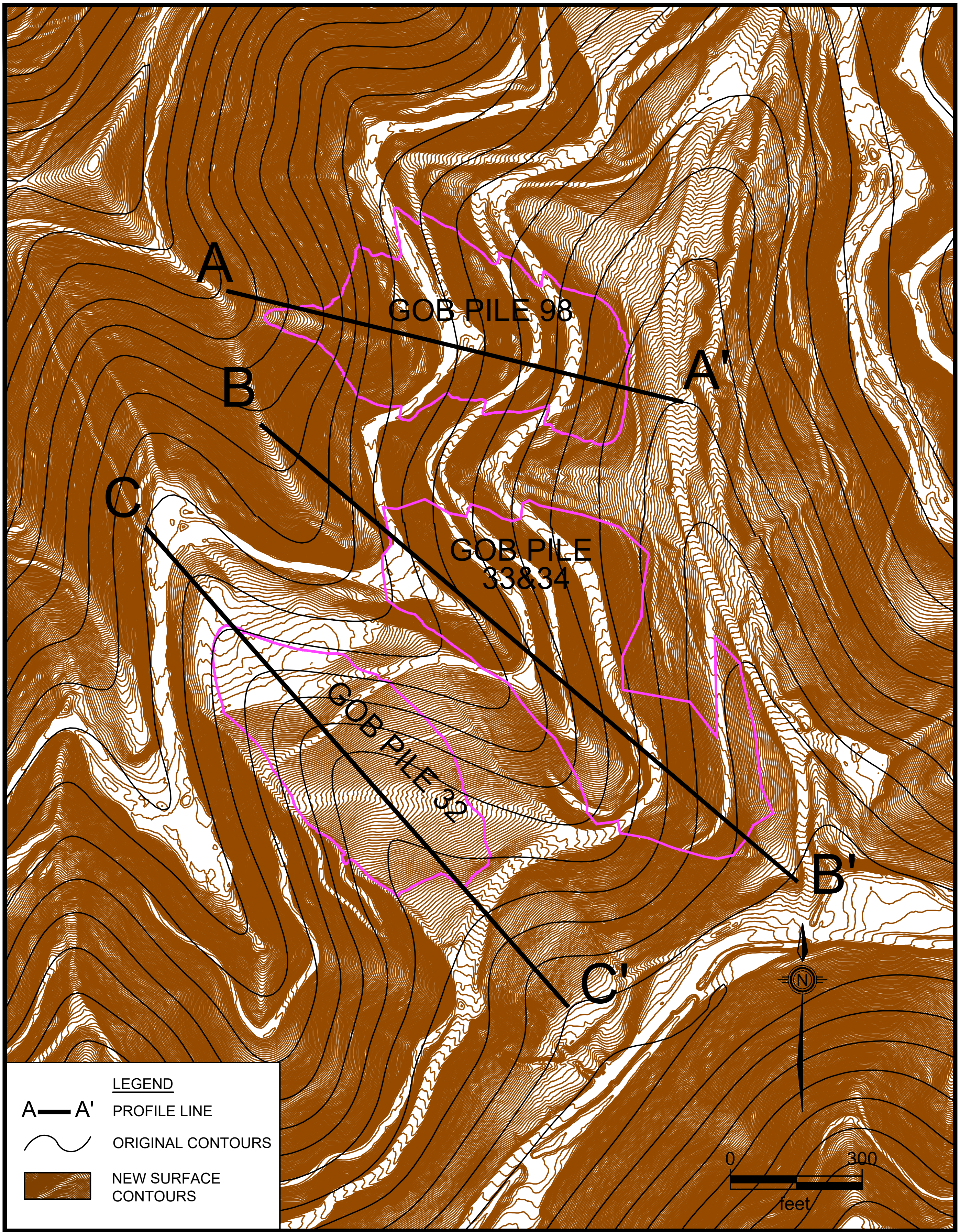
Big Stone Gap, Virginia

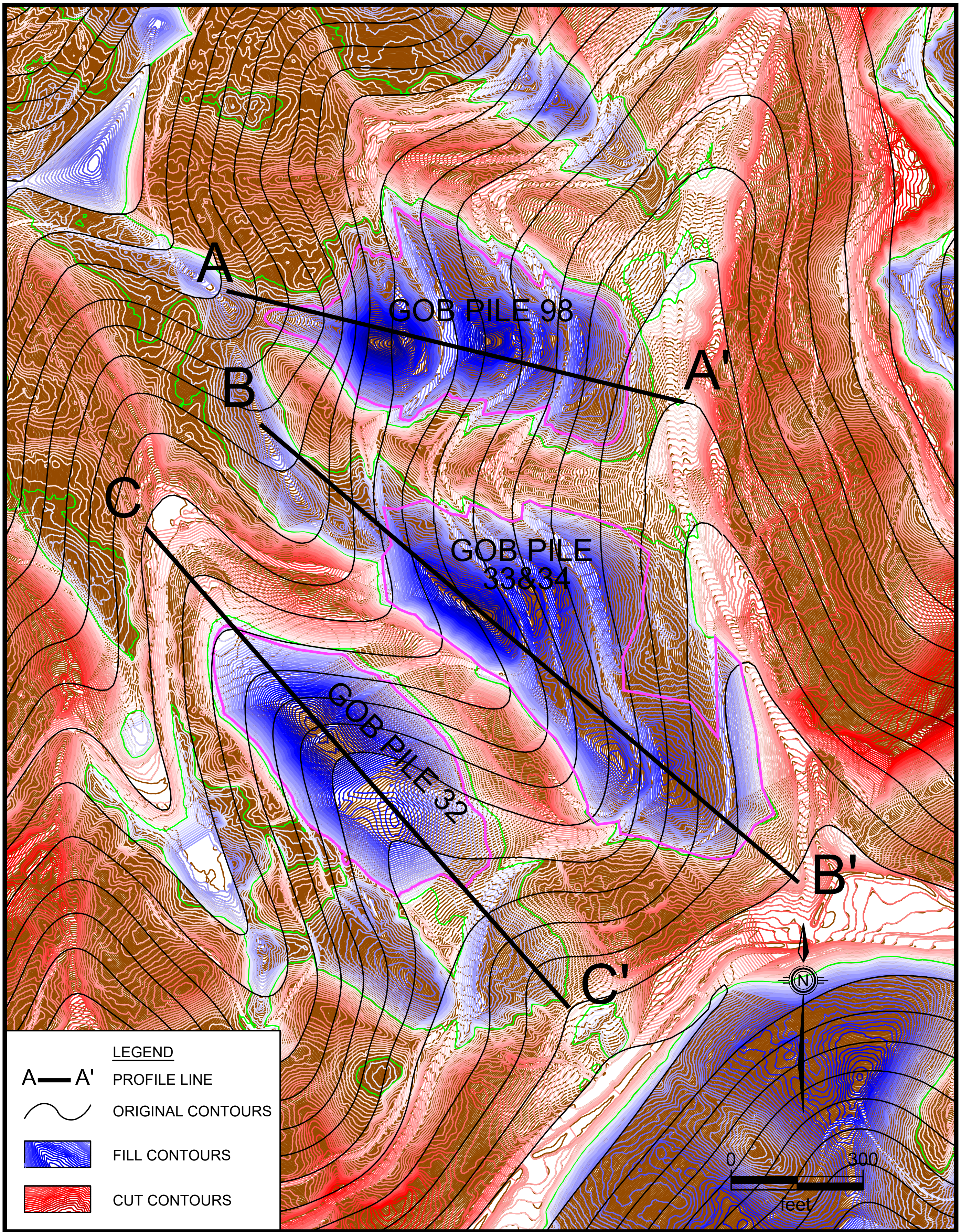
Exhibit 3F

GOB PILE 58
PROFILE C - C'



MARSHALL MILLER & ASSOCIATES	Drawn: SA Checked: SA Date: 9/2022 Scale: 1"=300' Project No.: VAEN100 File No. 32-33-34-98 CF.DWG	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia

Exhibit 4A
PLANVIEW
GOB PILES 32, 33, 34 AND 98



LEGEND

A — A' PROFILE LINE

ORIGINAL CONTOURS

FILL CONTOURS

CUT CONTOURS

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	32-33-34-98 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
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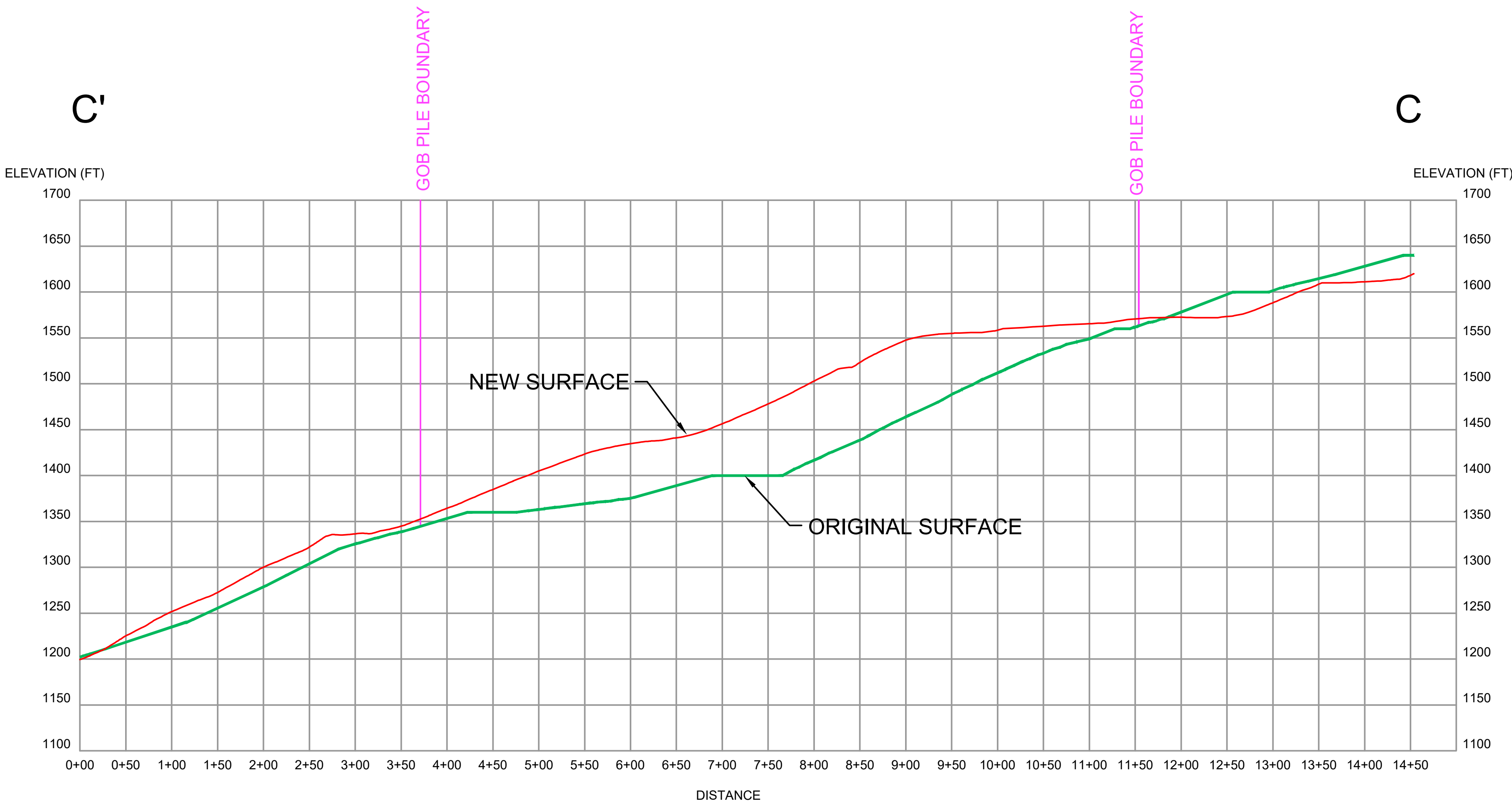
Big Stone Gap, Virginia

Exhibit 4B
PLANVIEW
GOB PILES 32, 33, 34 AND 98



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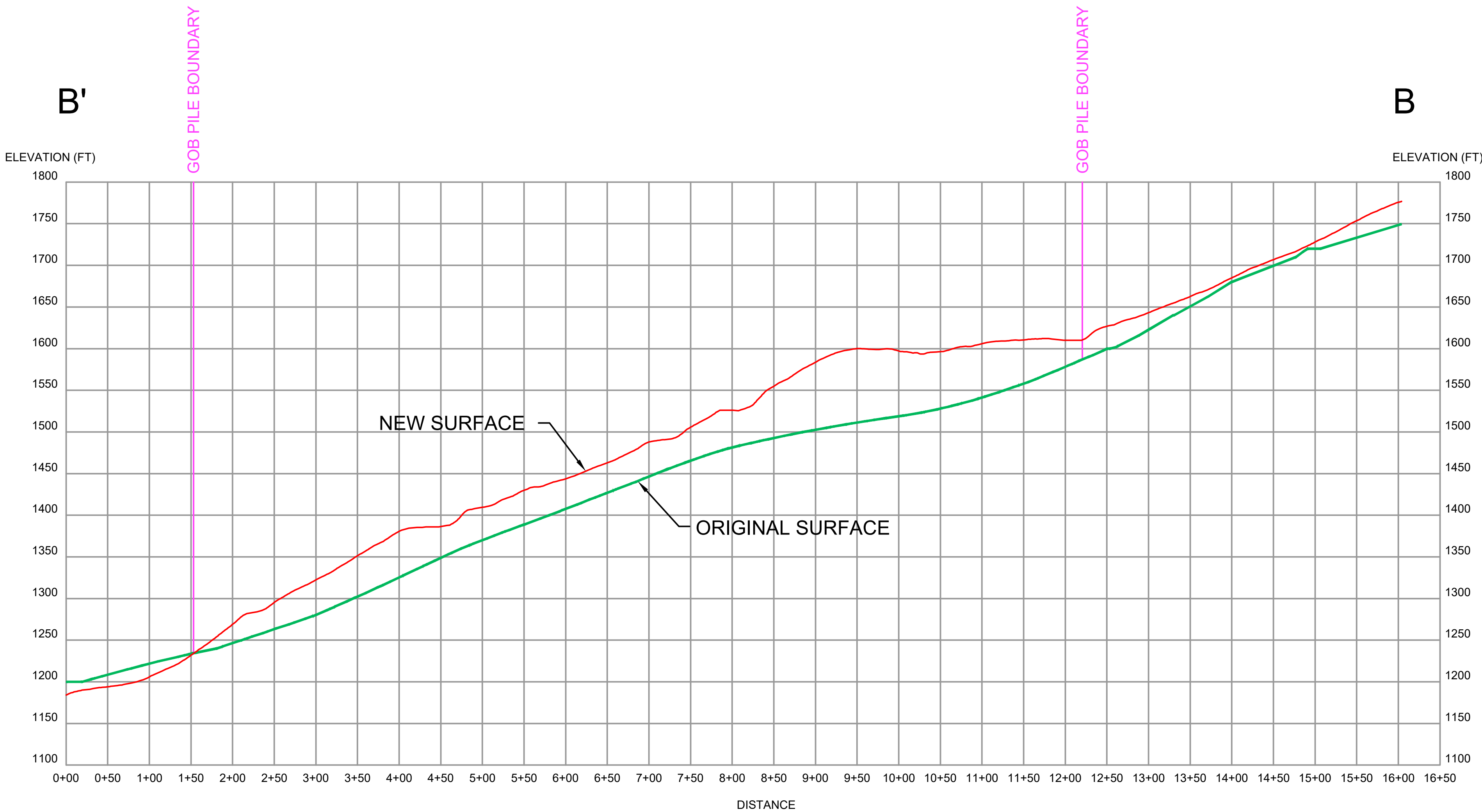
Date:	9/2022
Scale:	AS SHOWN
Project No.:	XXXXX
File No.32-33-34-98 CF.DWG	

Company
Project

Place, State

Exhibit 4C
GOB PILE 33 AND 34
PROFILE B - B'



MARSHALL MILLER & ASSOCIATES

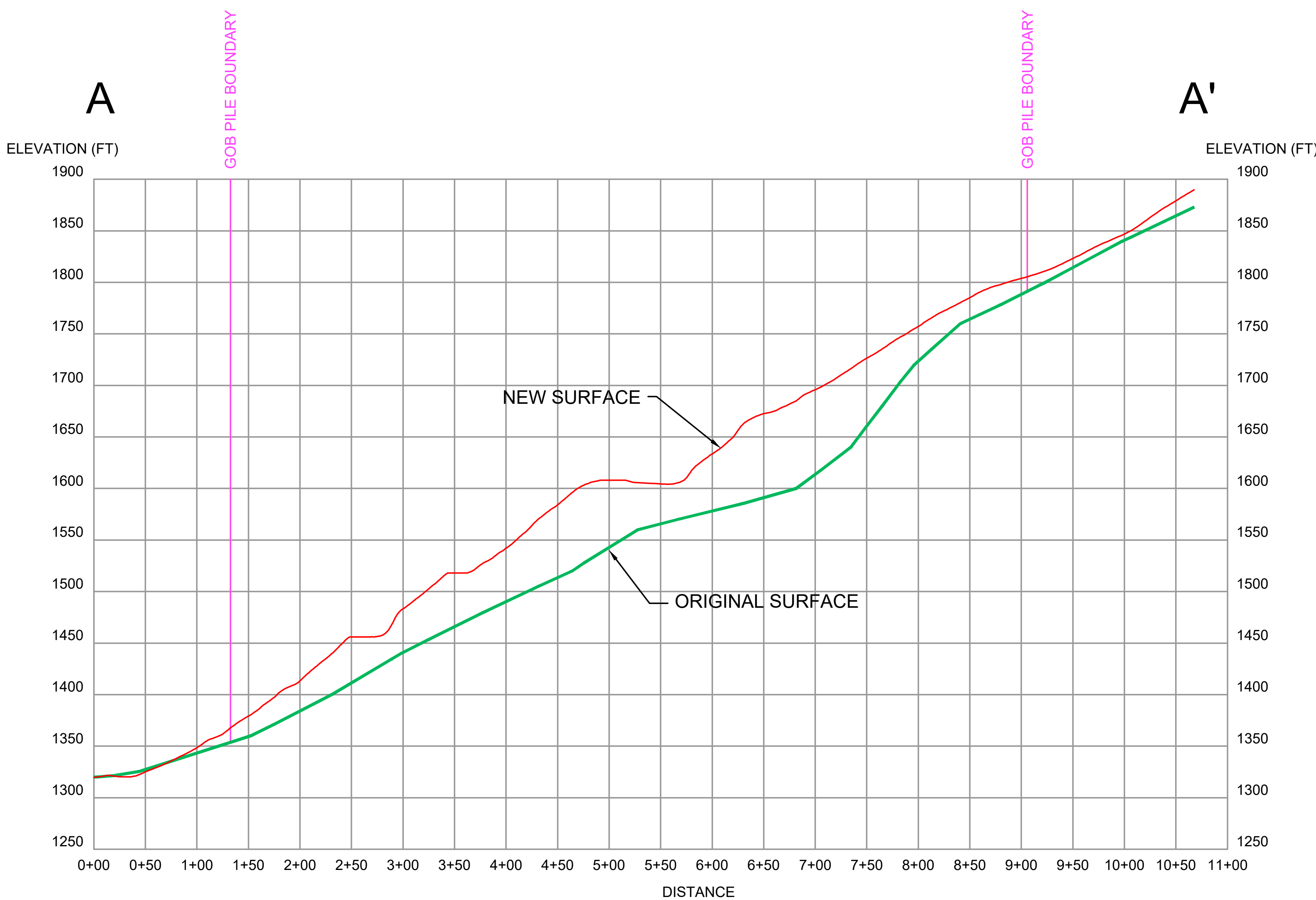
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	XXXXX
File No.32-33-34-98 CF.DWG	

Company
Project

Place, State

Exhibit 4D

GOB PILE 33 AND 34
PROFILE B - B'



MARSHALL MILLER & ASSOCIATES®

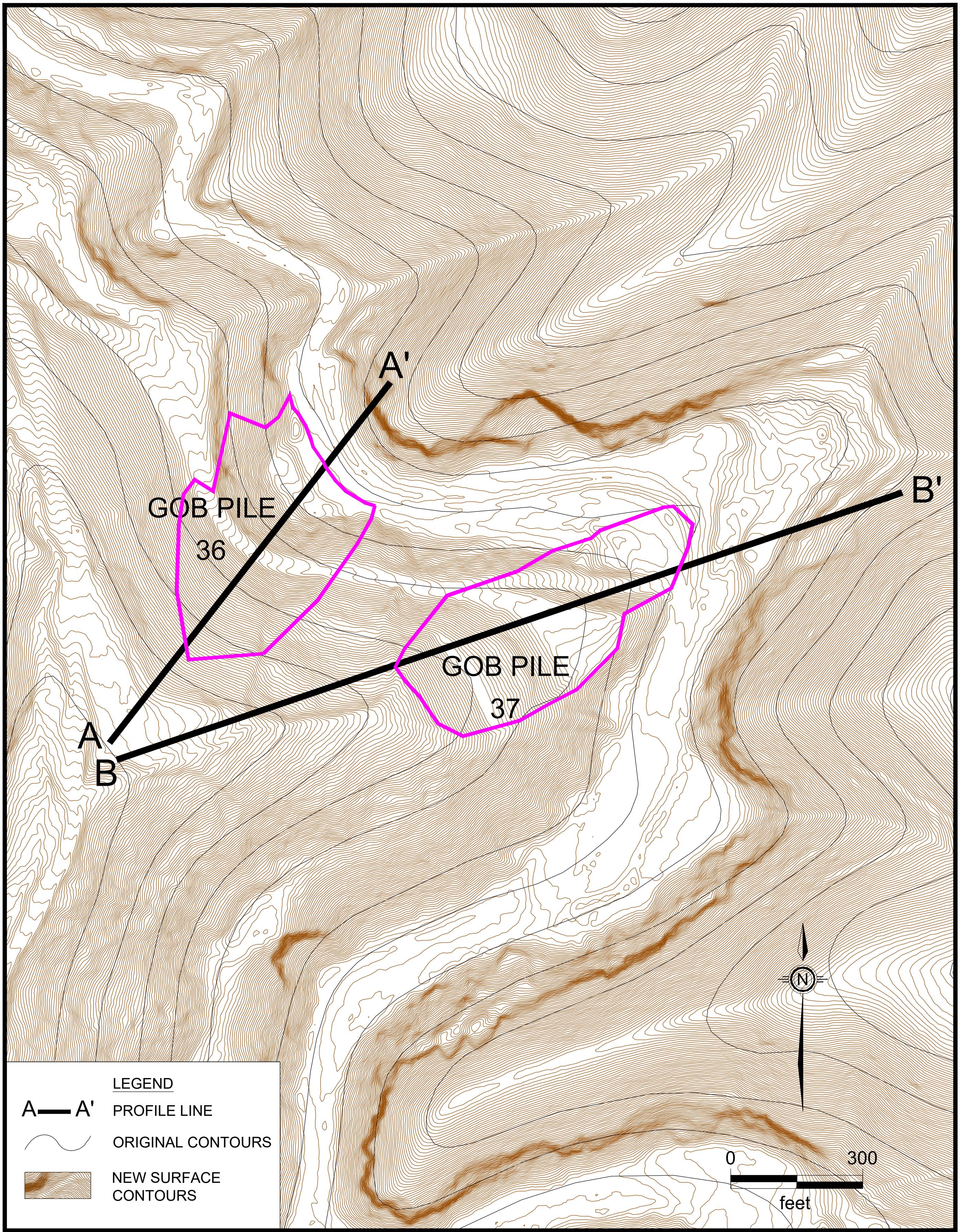
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	32-33-34-98 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

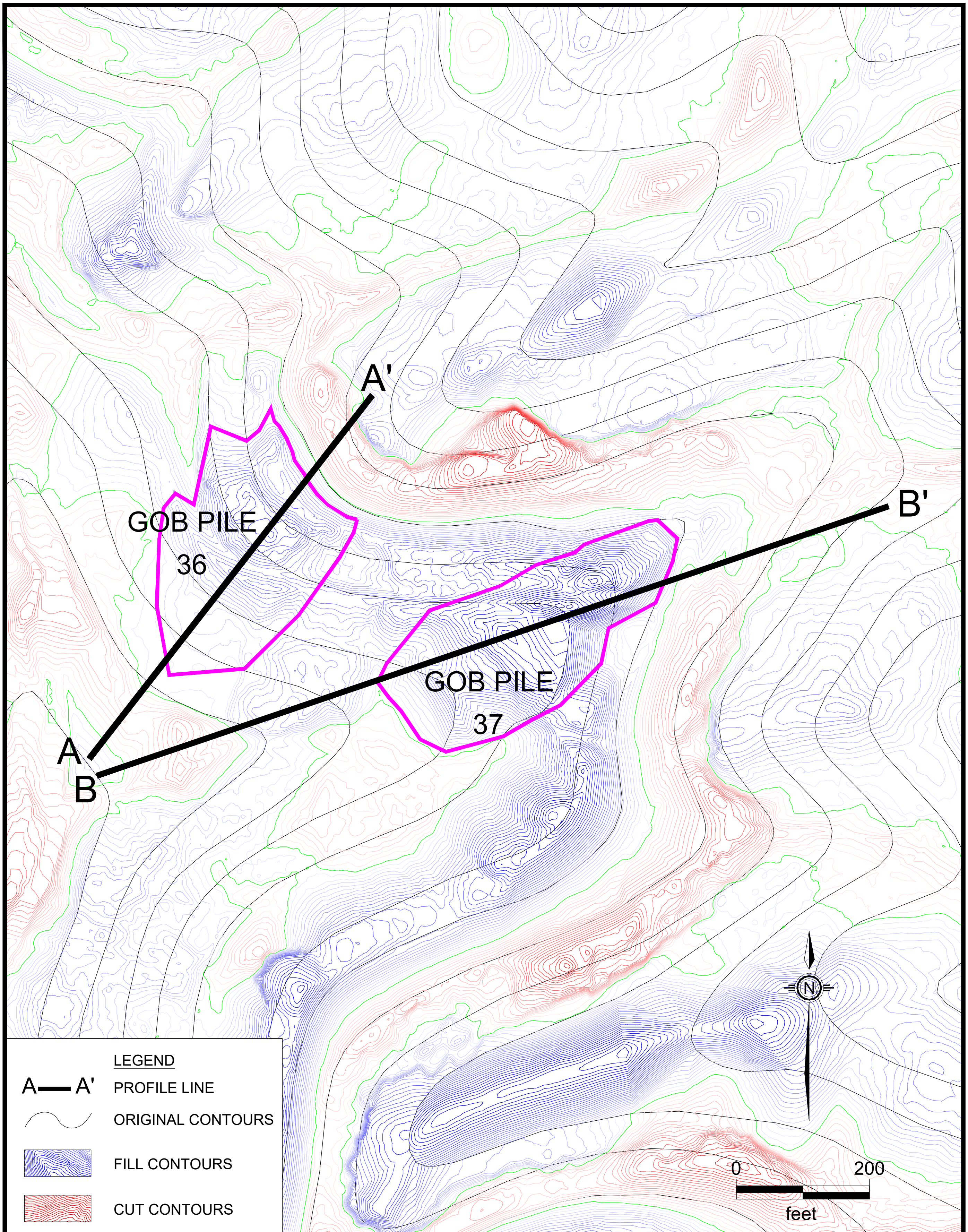
Big Stone Gap, Virginia

Exhibit 4E

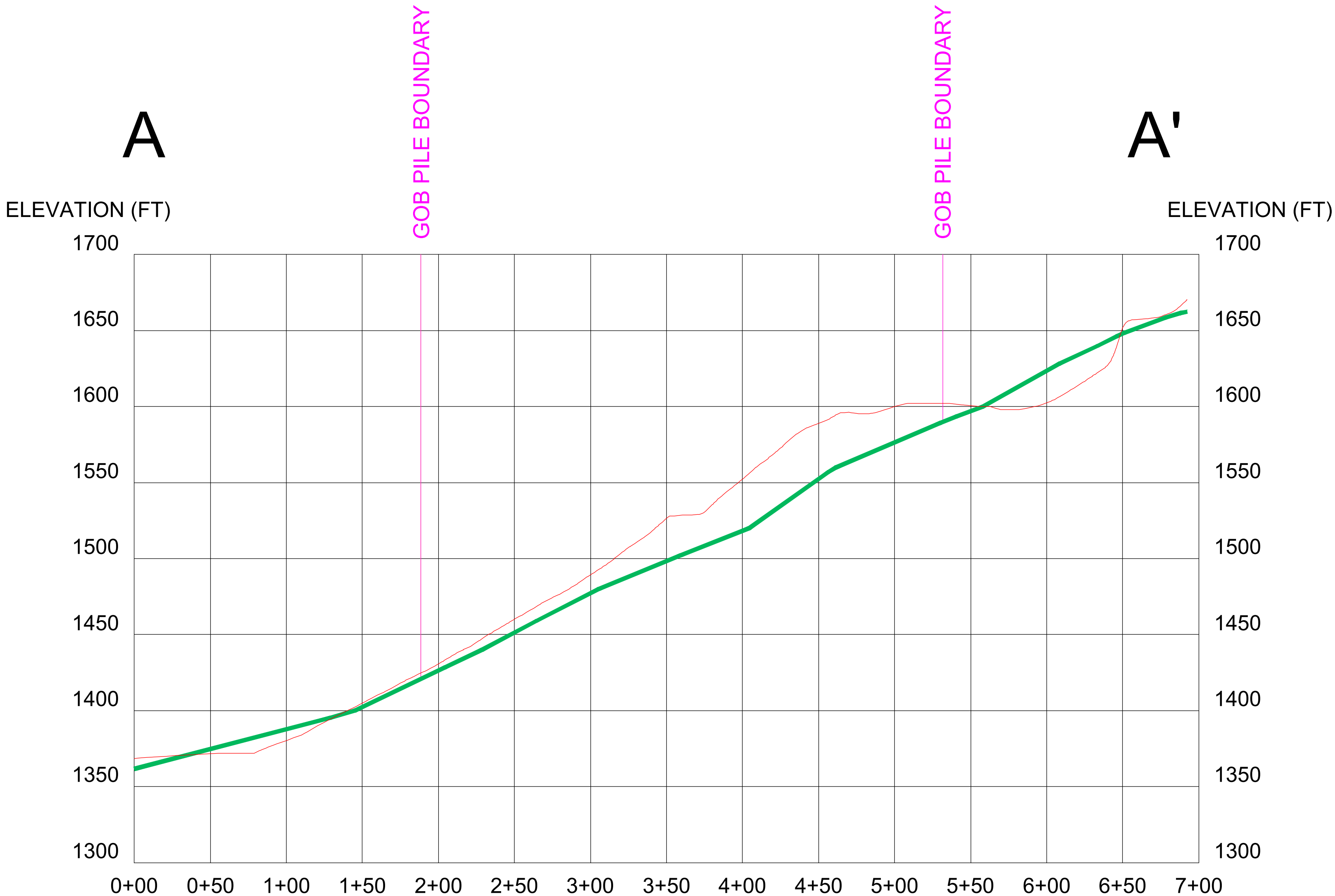
GOB PILE 98
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES	Drawn: SA Checked: SA Date: 9/2022 Scale: 1"=200' Project No.: VAEN100 File No. 36-37 NSC.DWG	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 5A PLANVIEW GOB PILES 36 AND 37



MARSHALL MILLER & ASSOCIATES	Drawn: SA Checked: SA Date: 9/2022 Scale: 1"=200' Project No.: VAEN100 File No. 36-37 CF.DWG	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 5B PLANVIEW GOB PILE 36 AND 37



MARSHALL MILLER & ASSOCIATES

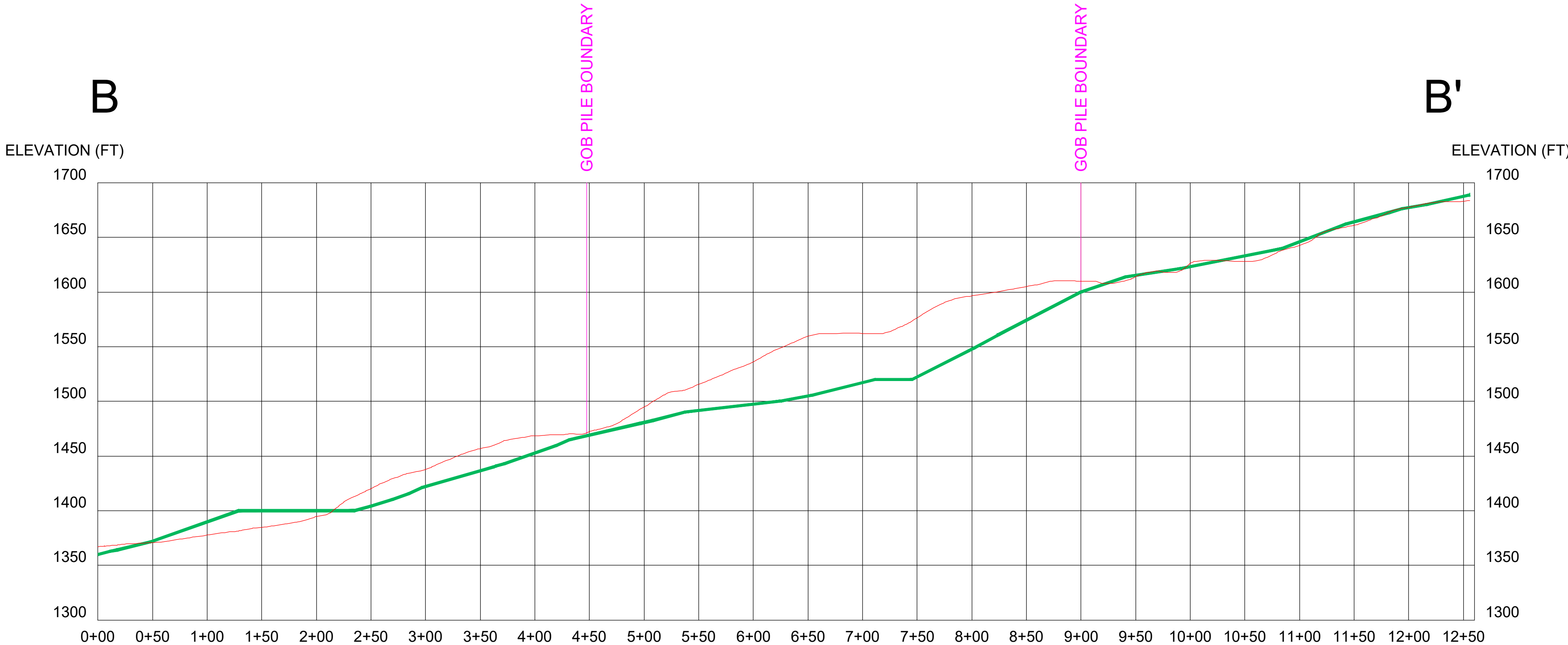
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	36-37 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 5C

GOB PILE 36
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES

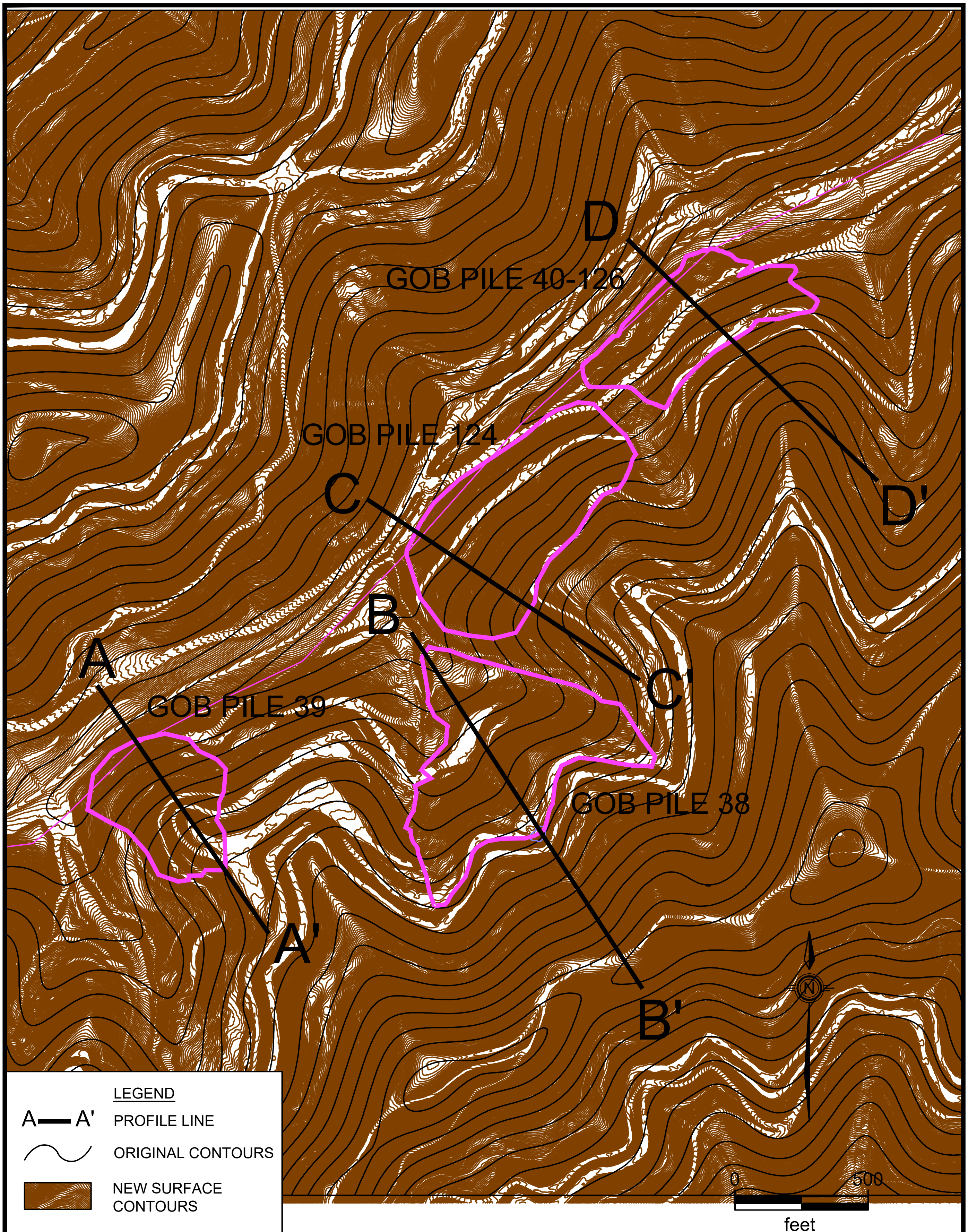
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	36-37 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 5D

GOB PILE 37
PROFILE B - B'



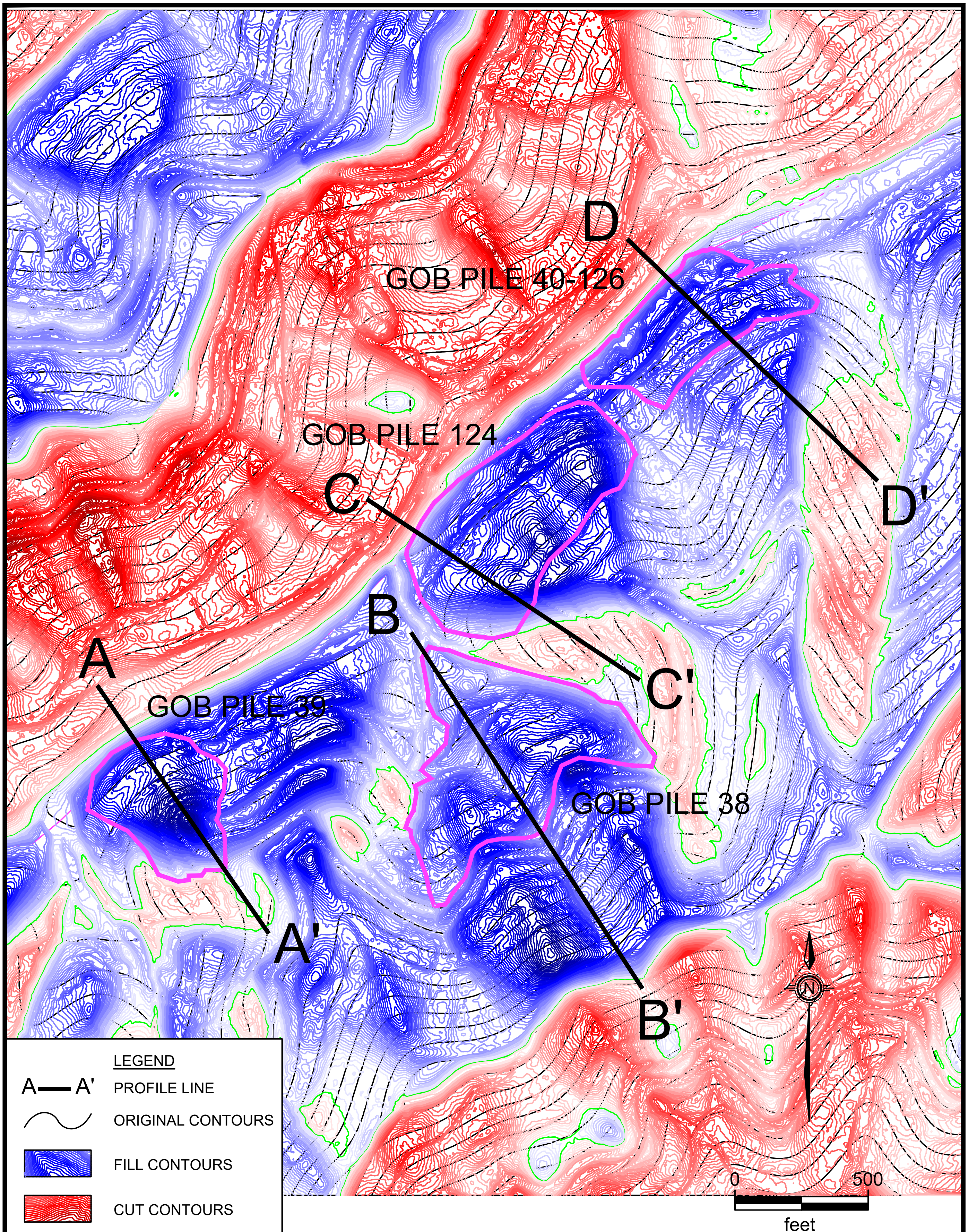
MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=500'
Project No.:	VAEN100
File No. 38-39-124-40-126 CF.DWG	

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 6A

PLANVIEW GOB PILES
39, 38, 124 AND 40-126



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
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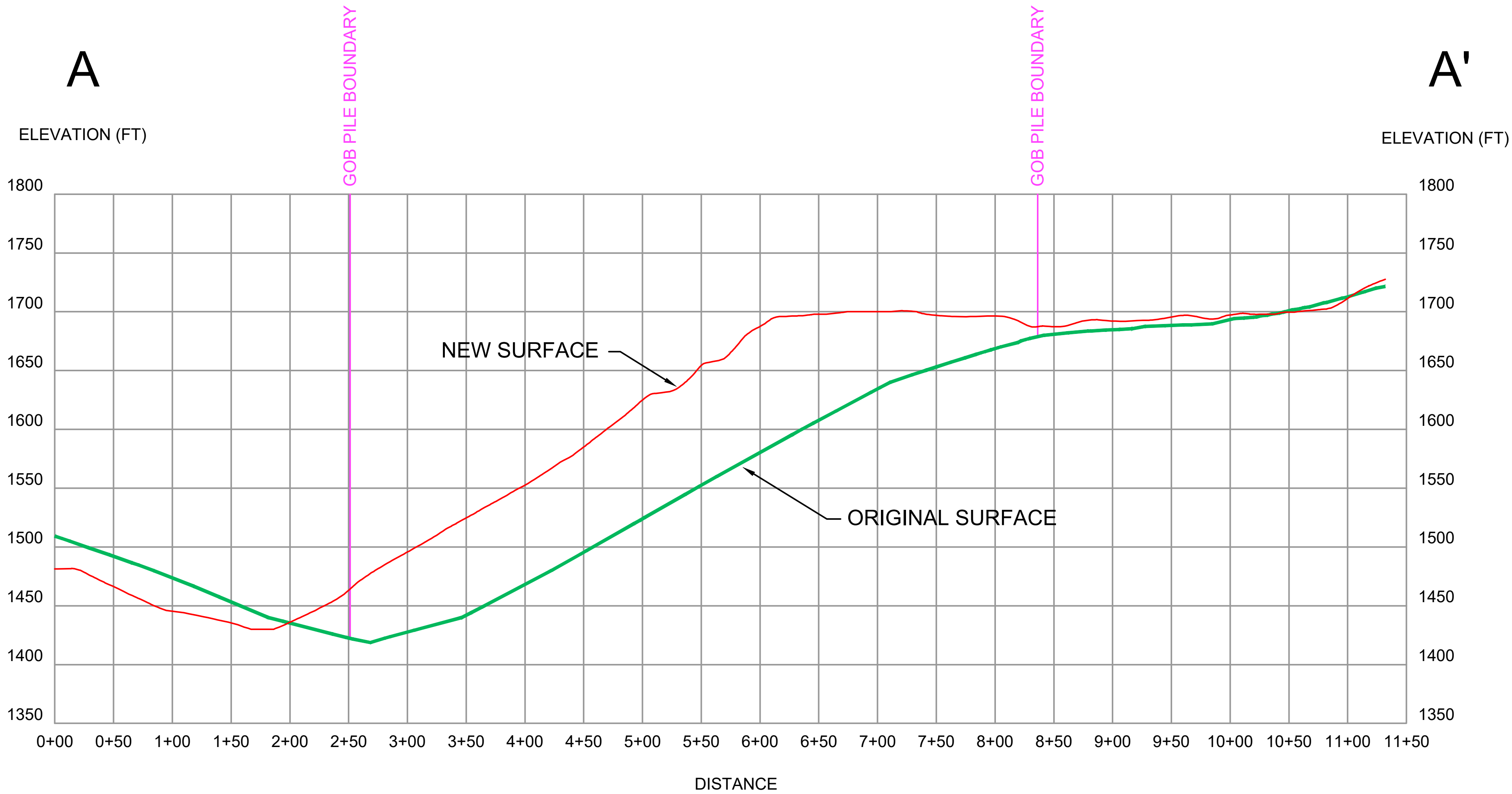
Date:	9/2022
Scale:	1"=500'
Project No.:	VAEN100
File No. 38-39-124-40-126 CF.DWG	

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 6B

PLANVIEW GOB PILES
39, 38, 124 AND 40-126



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	38-39-124-40-126 CF.DWG

Virginia Department Of Energy
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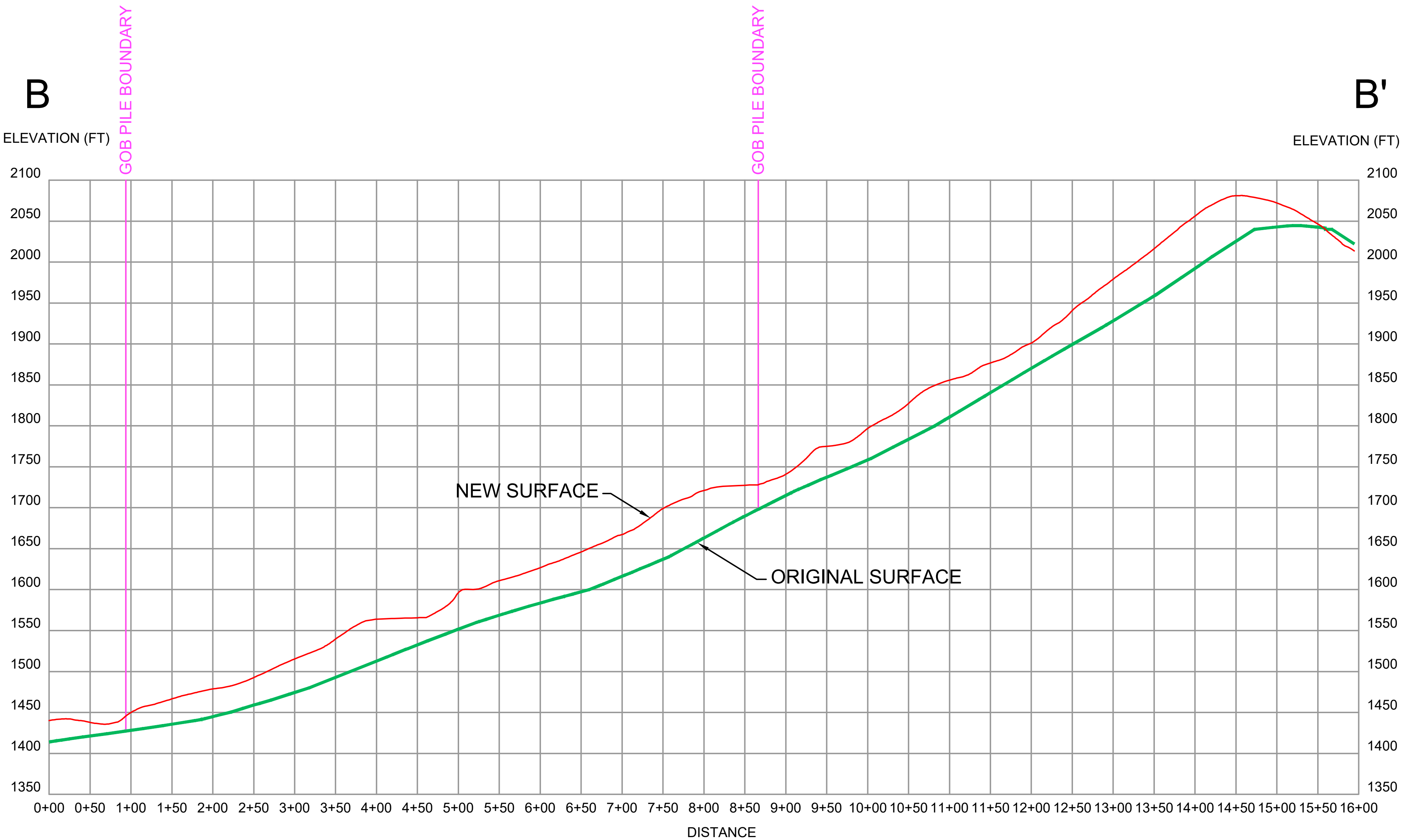
Big Stone Gap, Virginia

Exhibit 6C

GOB PILE 39
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	38-39-124-40-126 CF.DWG

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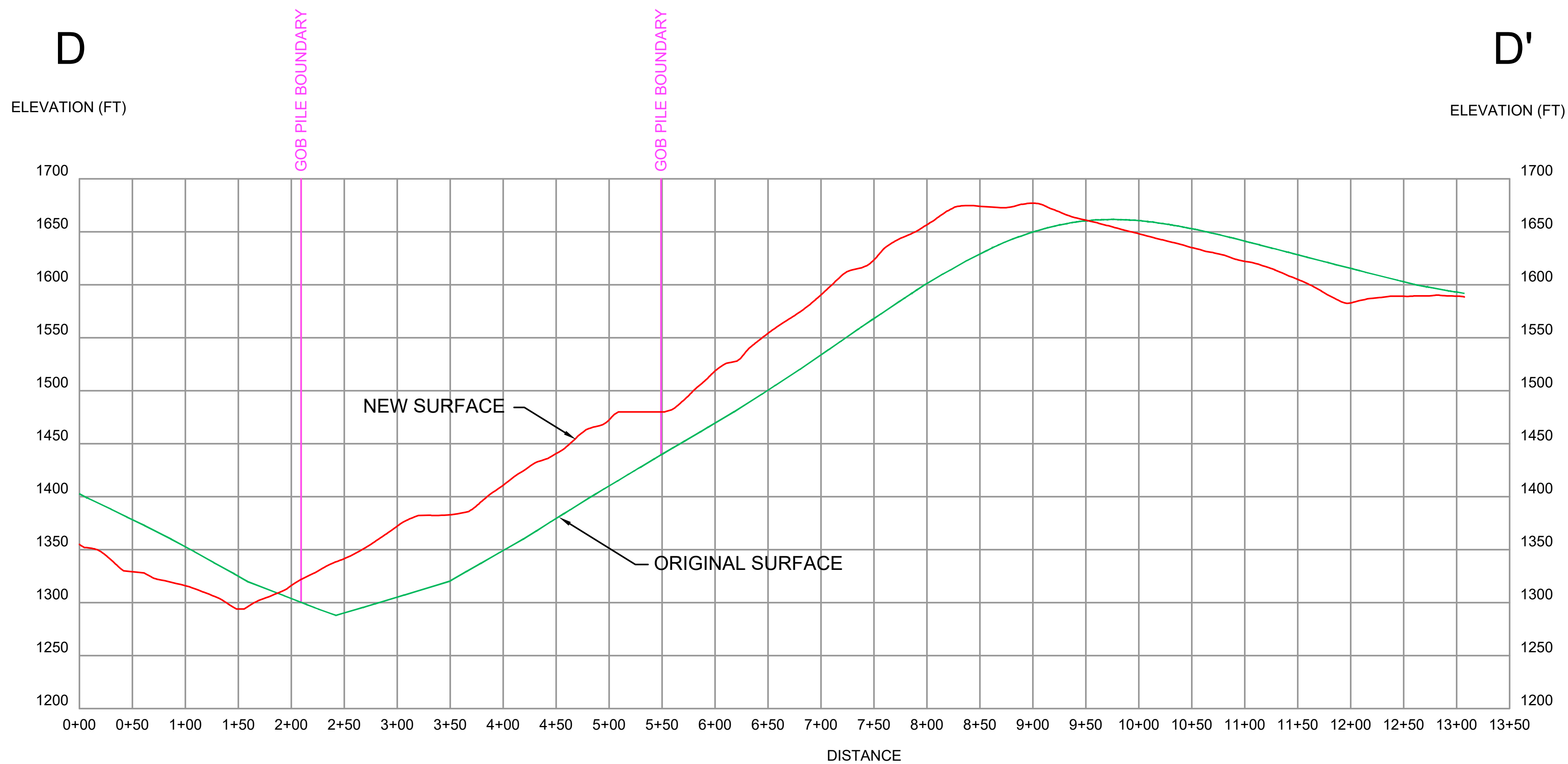
Exhibit 6D

GOB PILE 38
PROFILE B - B'



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Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	38-39-124-40-126 CF.DWG

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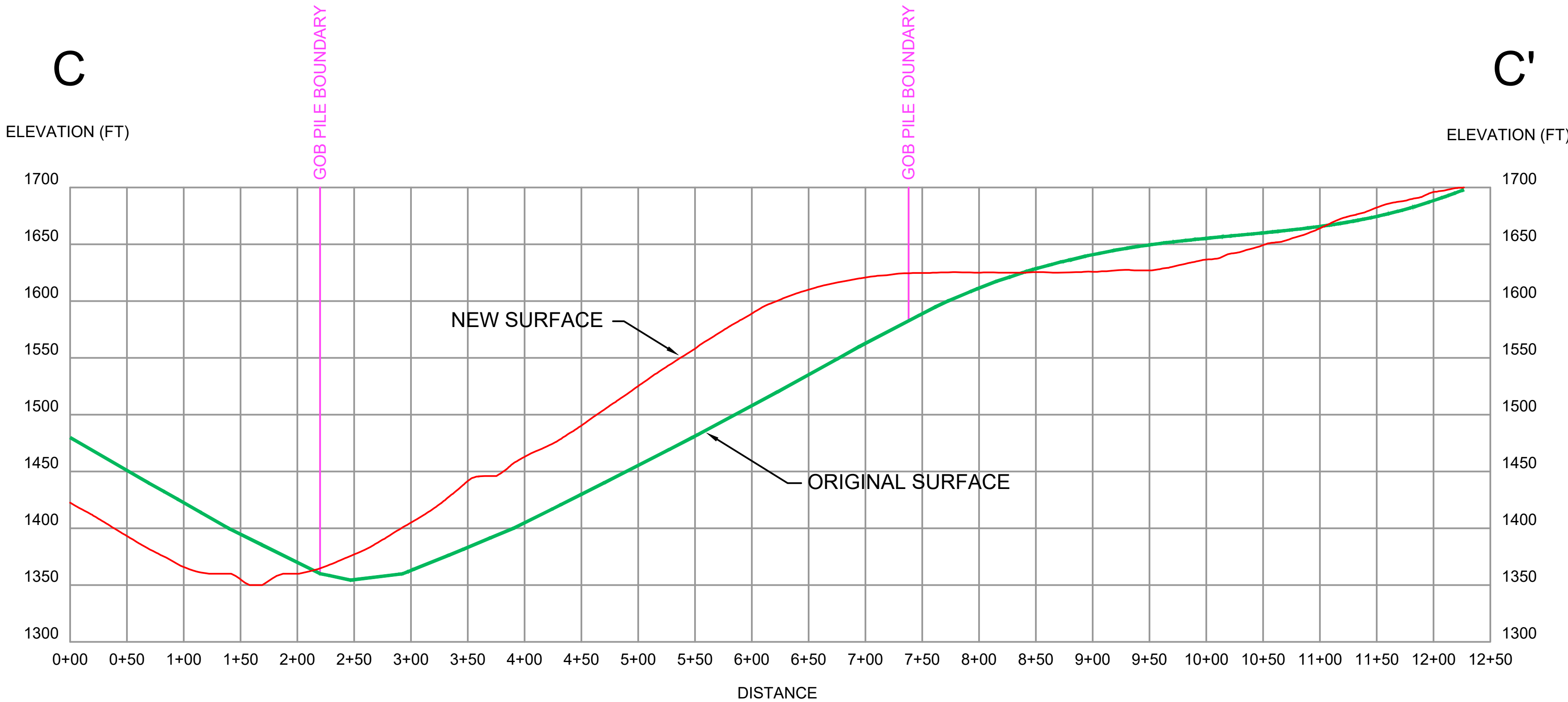
Exhibit 6E

GOB PILE 40-126
PROFILE D - D'



MARSHALL MILLER & ASSOCIATES®

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	38-39-124-40-126 CF.DWG

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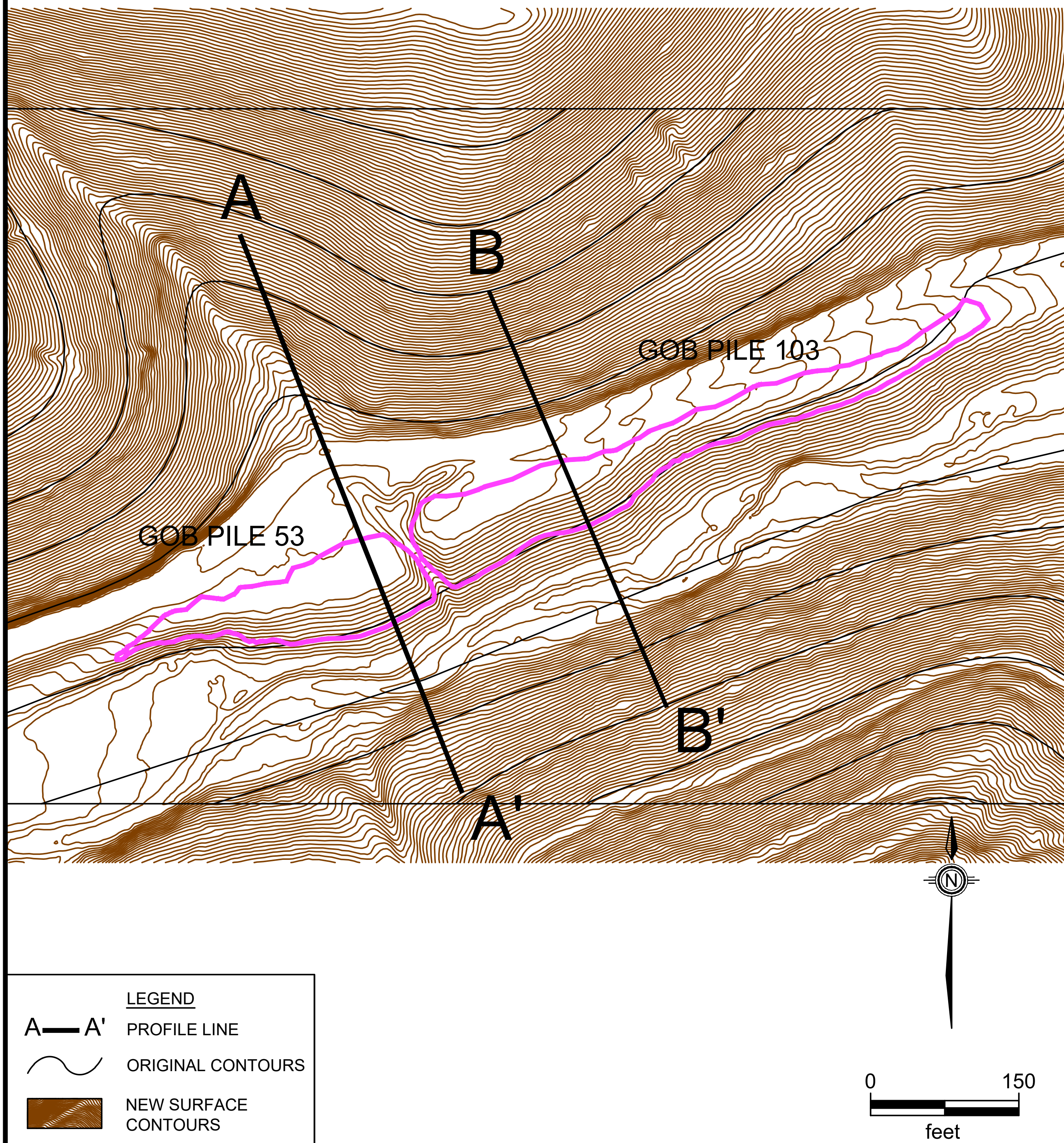
Exhibit 6F

GOB PILE 124
PROFILE C - C'



LEGEND

A — A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=150'
Project No.:	VAEN100
File No.	53-103 CF.DWG

Virginia Department Of Energy
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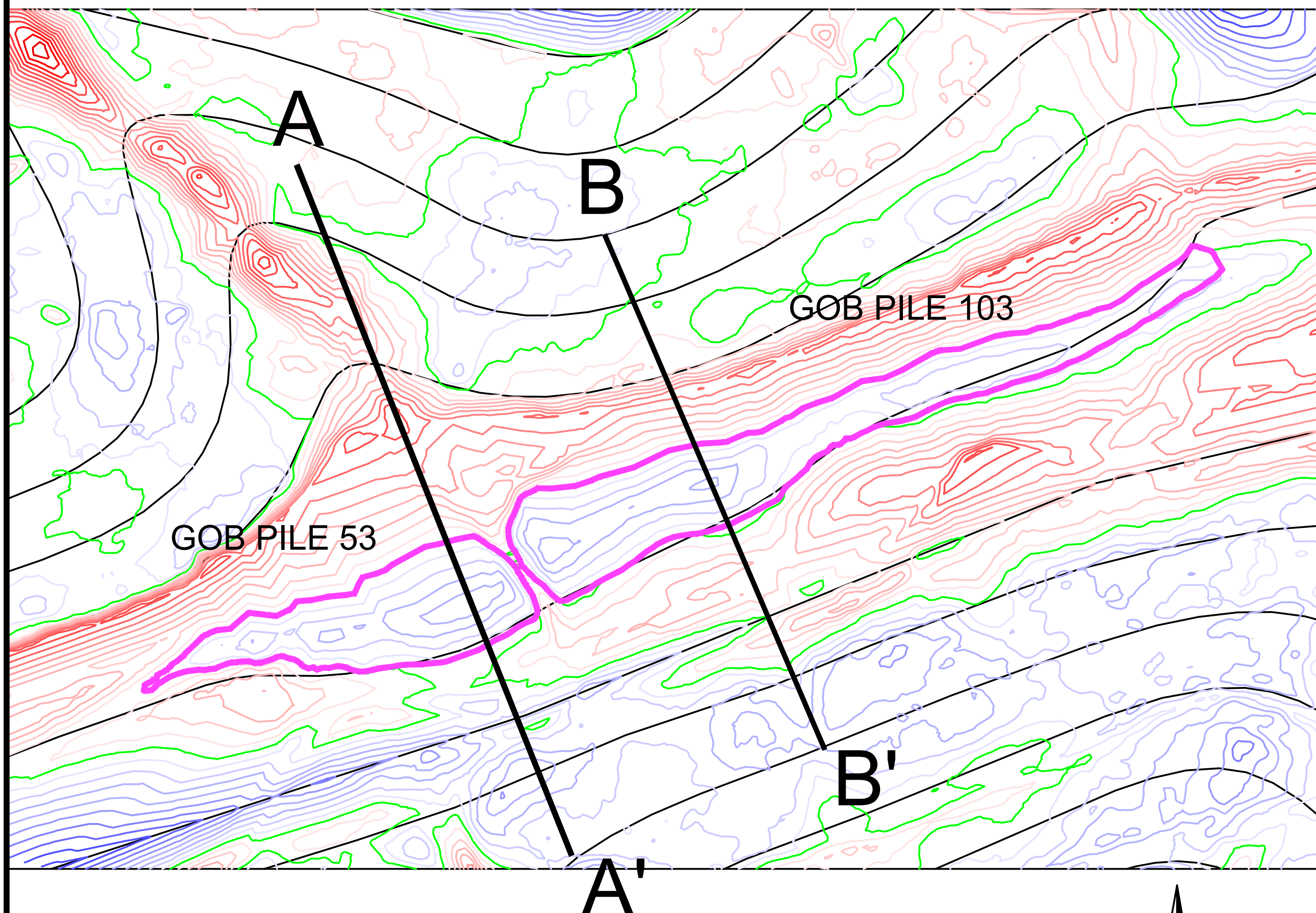
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 7A

PLANVIEW
GOB PILE 53 AND 103



LEGEND

A — A' PROFILE LINE

ORIGINAL CONTOURS

FILL CONTOURS

CUT CONTOURS

0 150
feet

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=150'
Project No.:	VAEN100
File No.	53-103 CF.DWG

Virginia Department Of Energy
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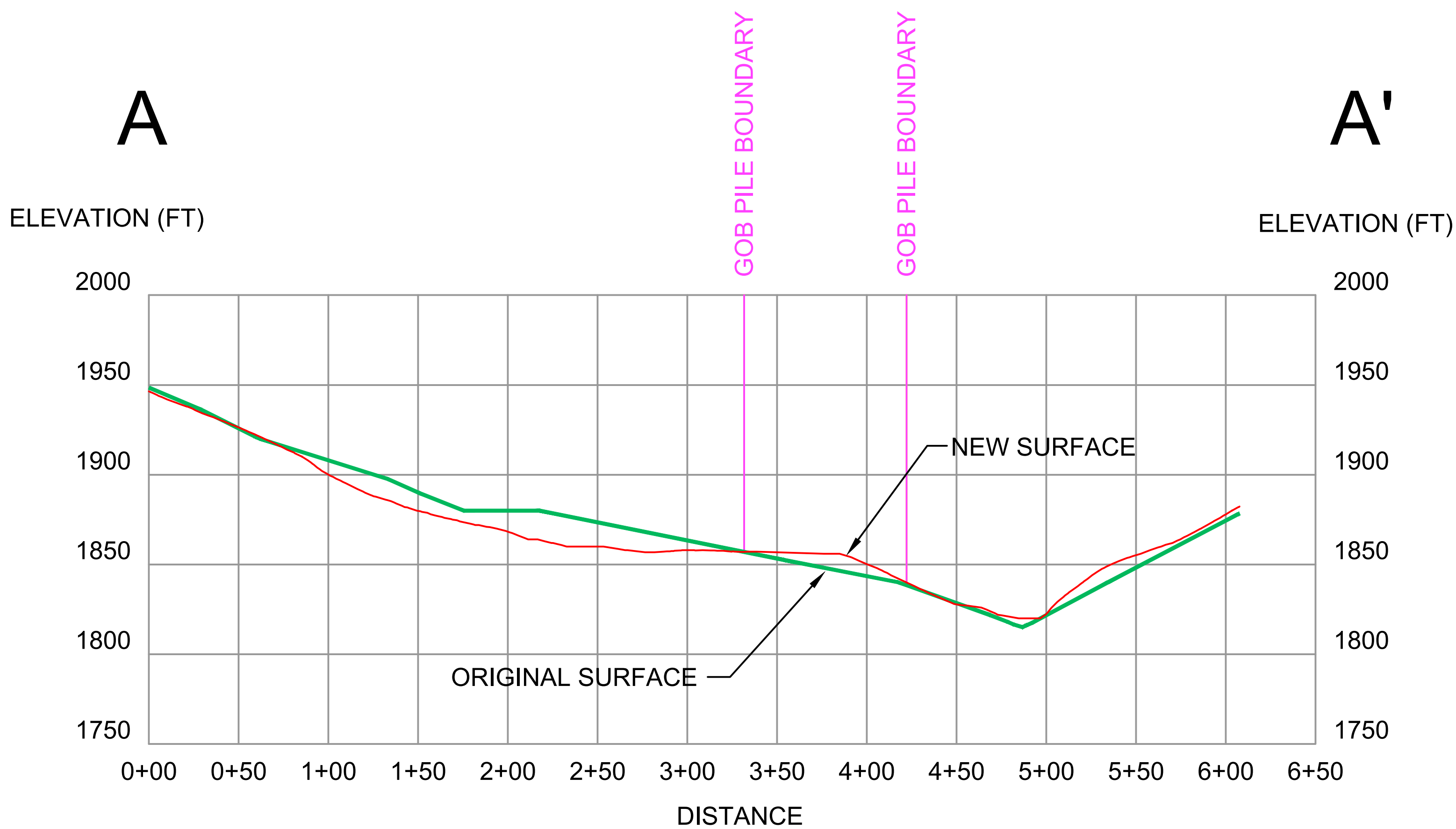
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 7B

PLANVIEW
GOB PILE 53 AND 103



MARSHALL MILLER & ASSOCIATES

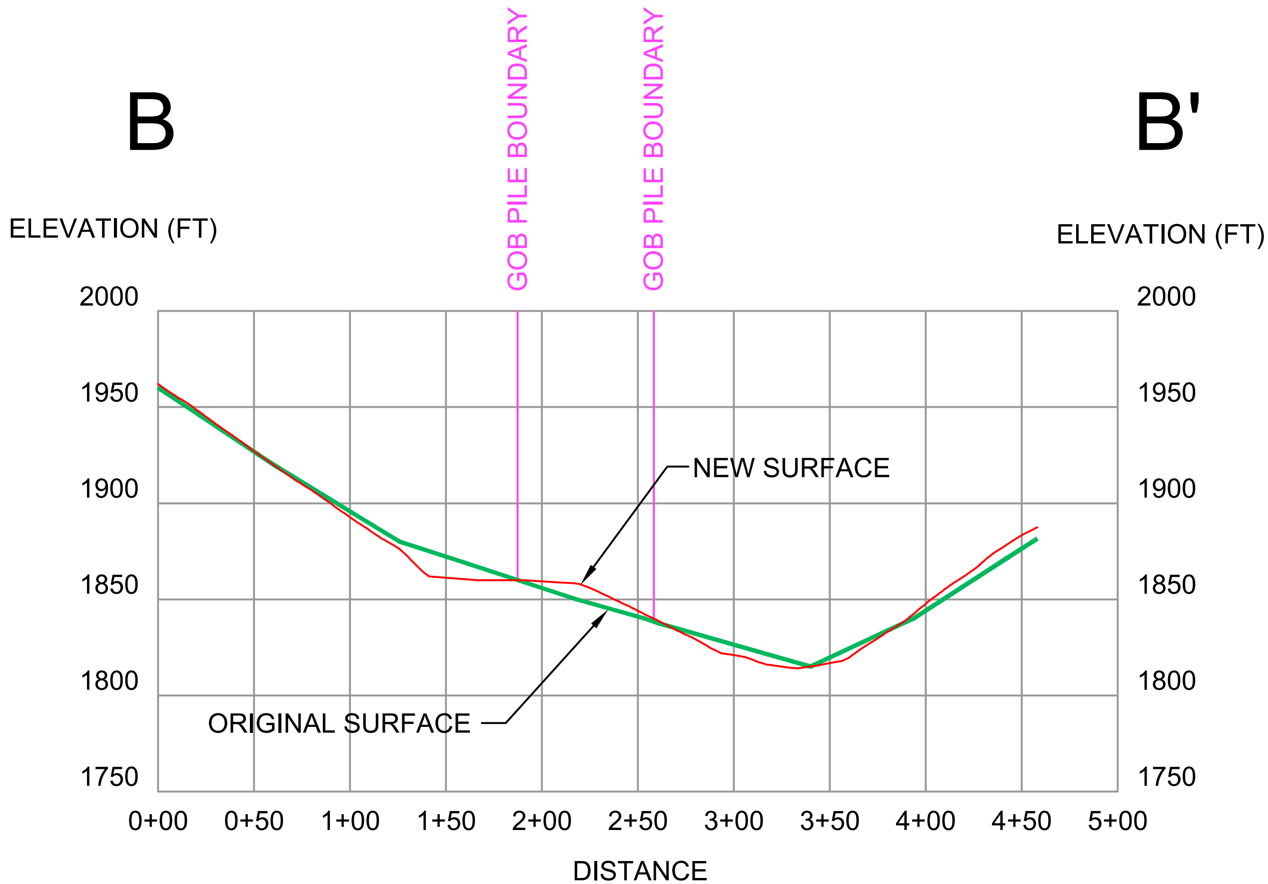
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	53-103 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 7C

GOB PILE 53
PROFILE A - A'



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Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	53-103 CF.DWG

Virginia Department Of Energy
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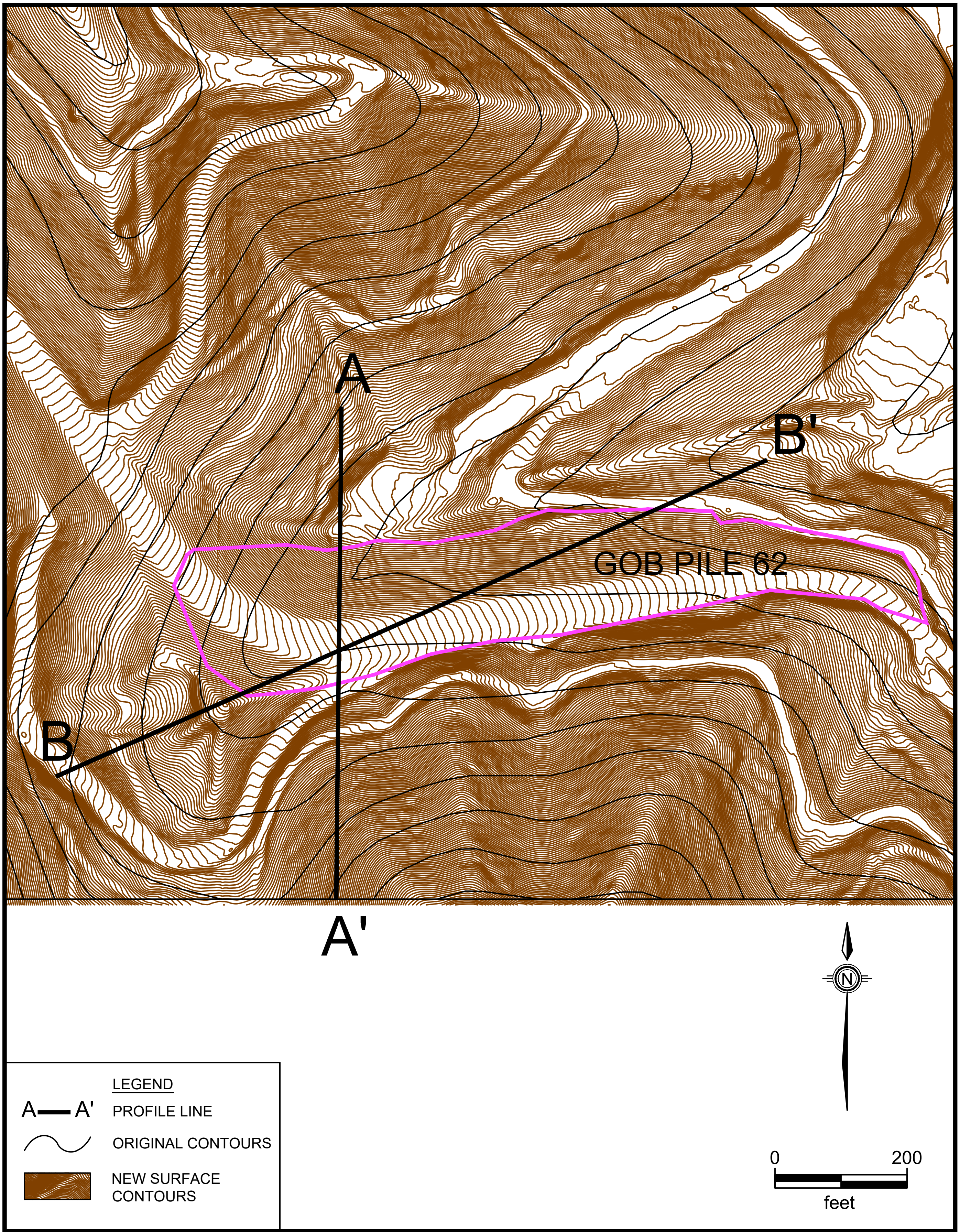
Exhibit 7D

GOB PILE 103
PROFILE A - A'



LEGEND

A — A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	62 CF.DWG

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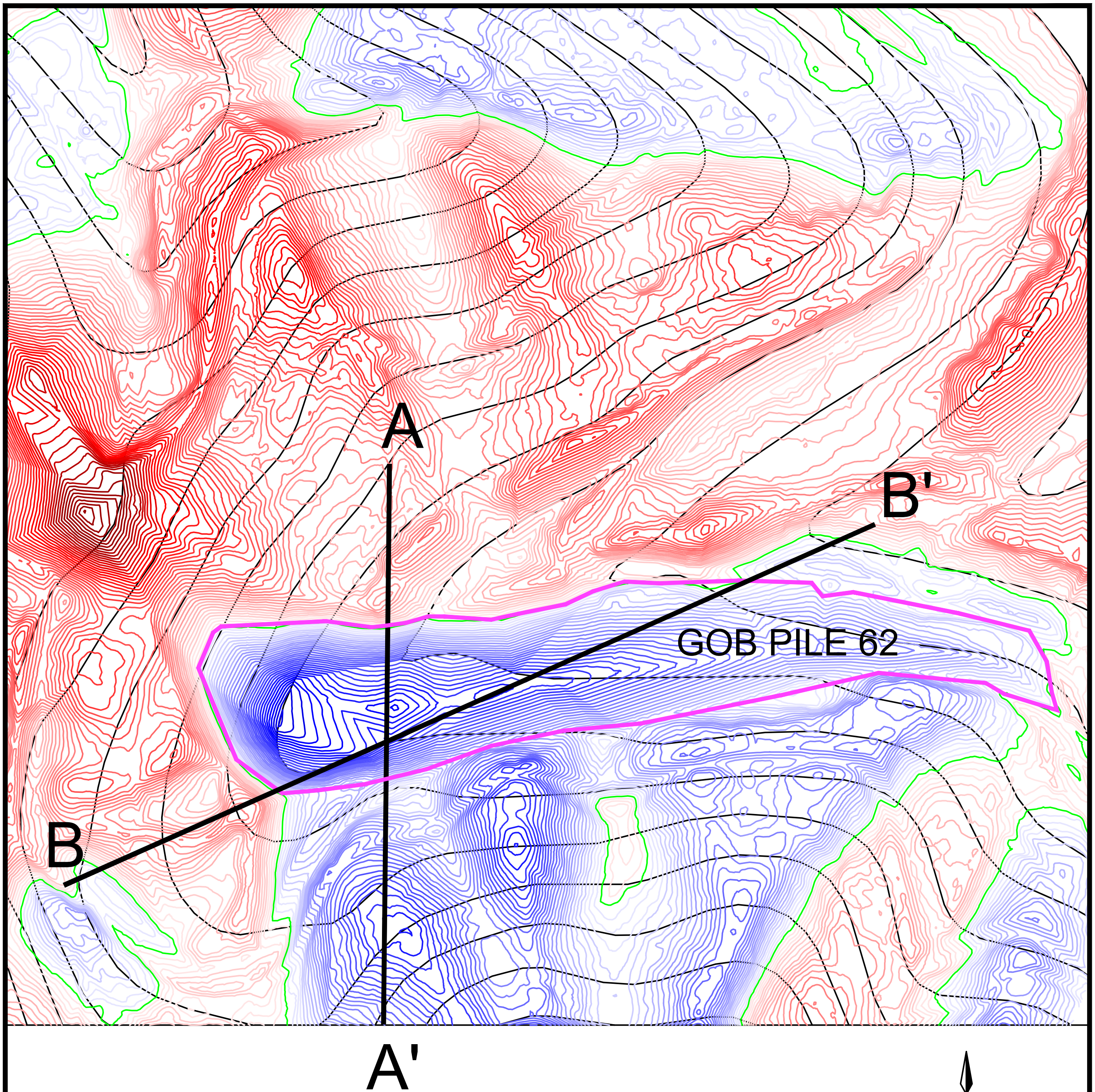
Exhibit 8A
PLANVIEW
GOB PILE 62



LEGEND

A—A' PROFILE LINE

ORIGINAL CONTOURS

FILL CONTOURS

CUT CONTOURS

N

0 200

feet

MARSHALL MILLER & ASSOCIATES©

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	62 CF.DWG

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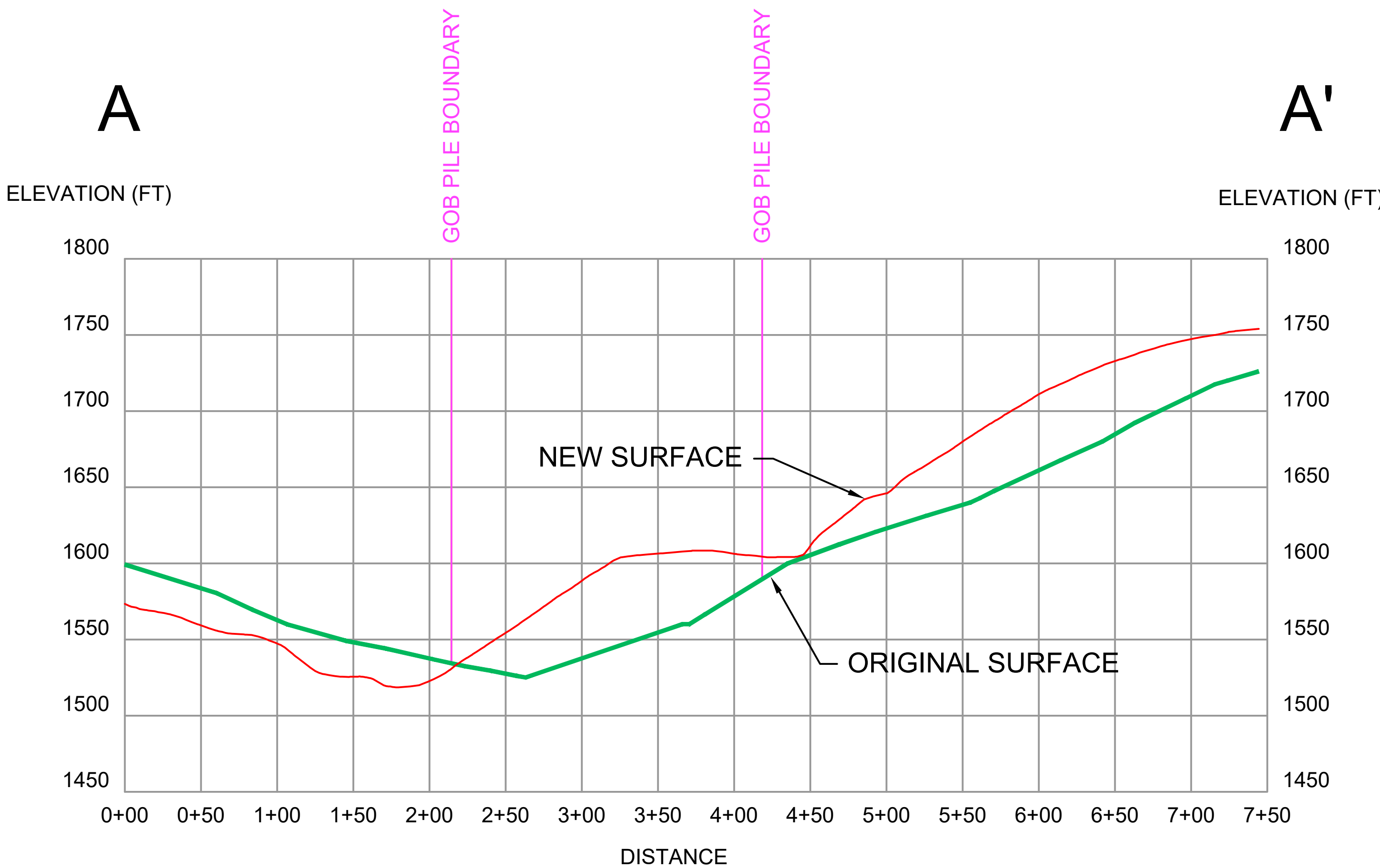
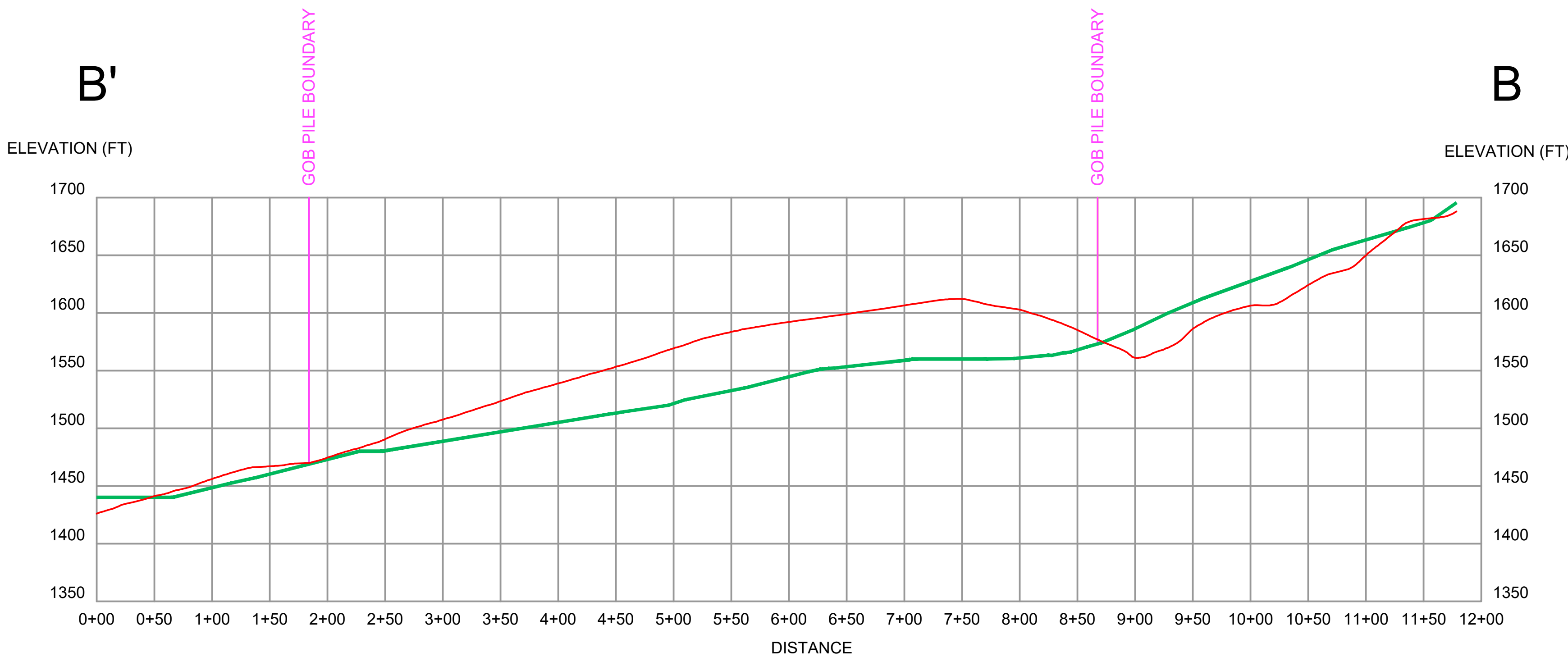
Big Stone Gap, Virginia

Exhibit 8B

PLANVIEW
GOB PILE 62



Drawn: SA		Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 8C GOB PILE 62 PROFILE A - A'
Checked: SA			
Date: 9/2022			
Scale: AS SHOWN			
Project No.: VAEN100			
File No. 62 CF.DWG			



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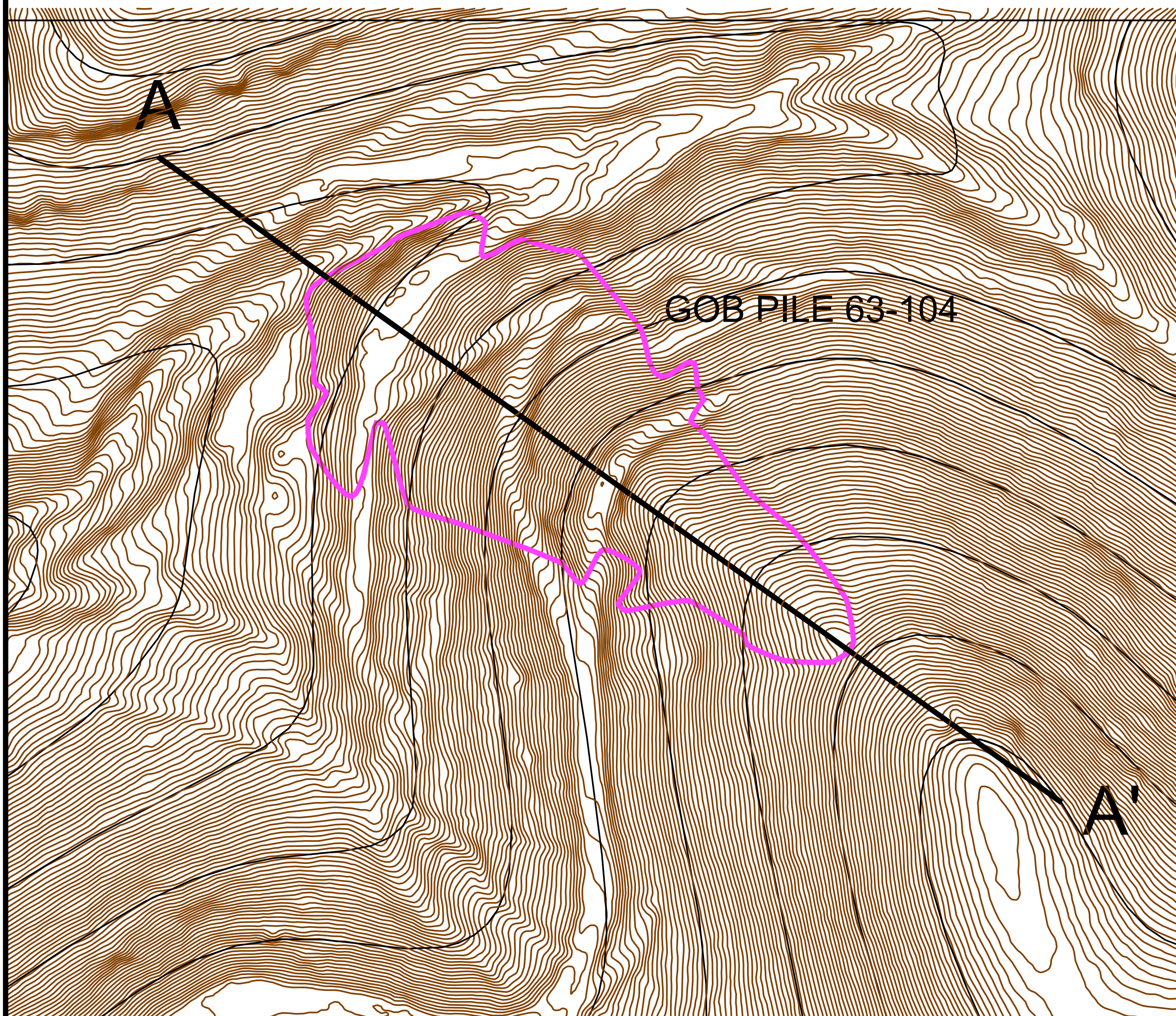
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	62 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 8D

GOB PILE 62
PROFILE B - B'



LEGEND

A—A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

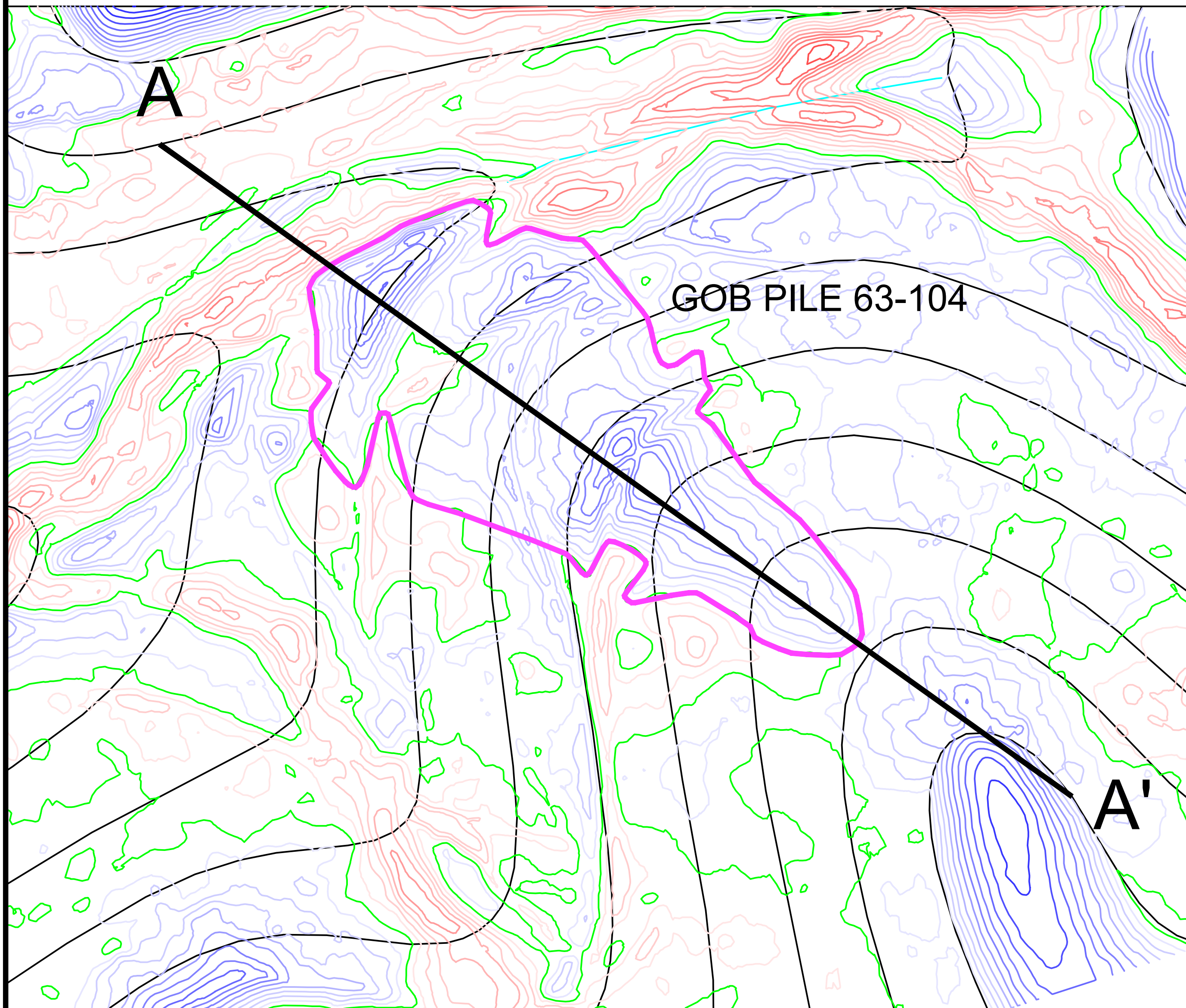
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=125'
Project No.:	VAEN100
File No.	63-104 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 9A

PLANVIEW
GOB PILE 63-104



LEGEND

A — A'	PROFILE LINE
	ORIGINAL CONTOURS
	FILL CONTOURS
	CUT CONTOURS

0 125
feet

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=125'
Project No.:	VAEN100
File No.	63-104 CF.DWG

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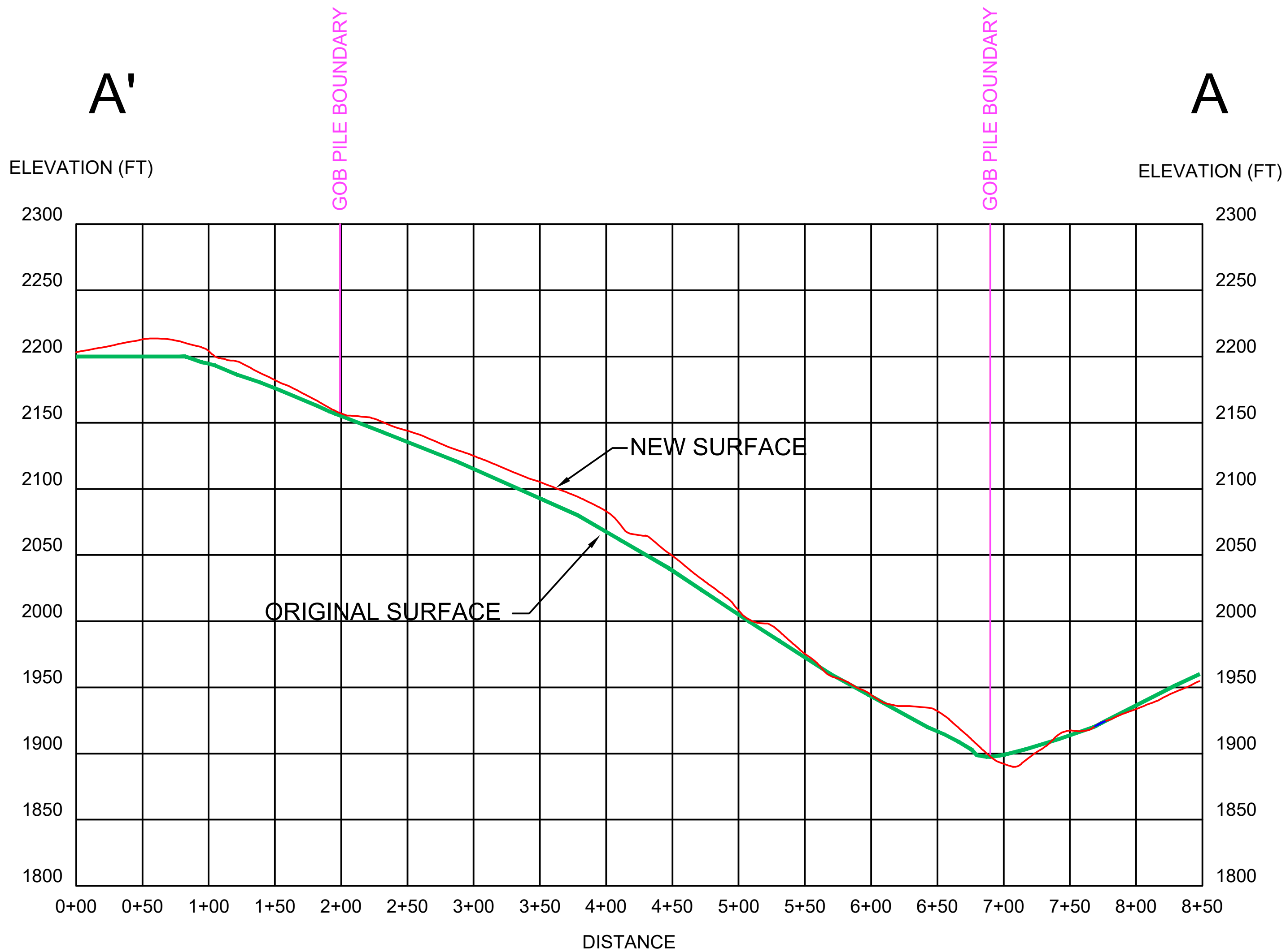
Big Stone Gap, Virginia

Exhibit 9B
PLANVIEW
GOB PILE 63-104



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	63-104 CF.DWG

Virginia Department Of Energy
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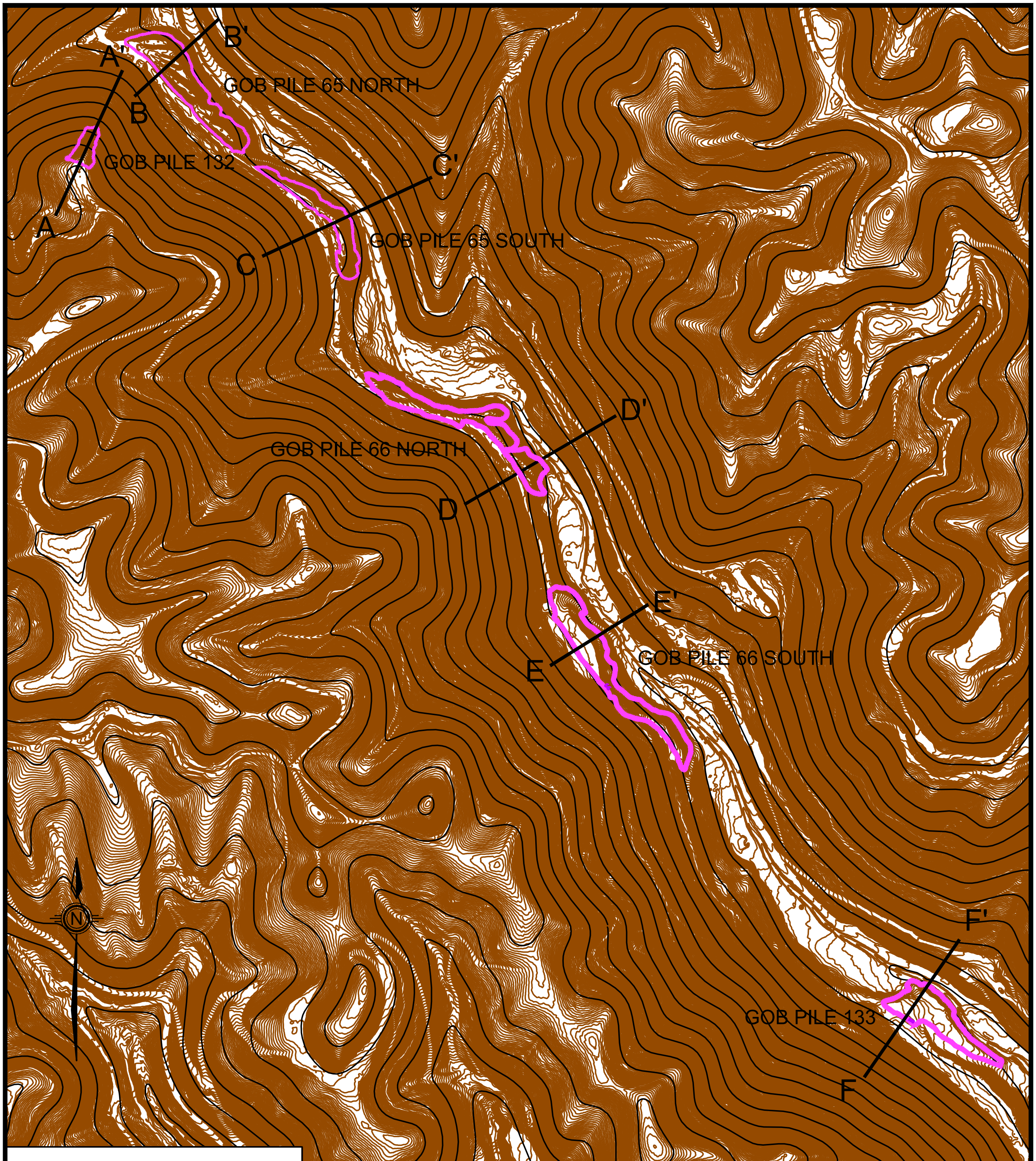
Exhibit 9C

GOB PILE 63-104
PROFILE A - A'



LEGEND

A—A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

0 600 feet

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=600'
Project No.:	VAEN100
File No65-66-132-133 CF.DWG	

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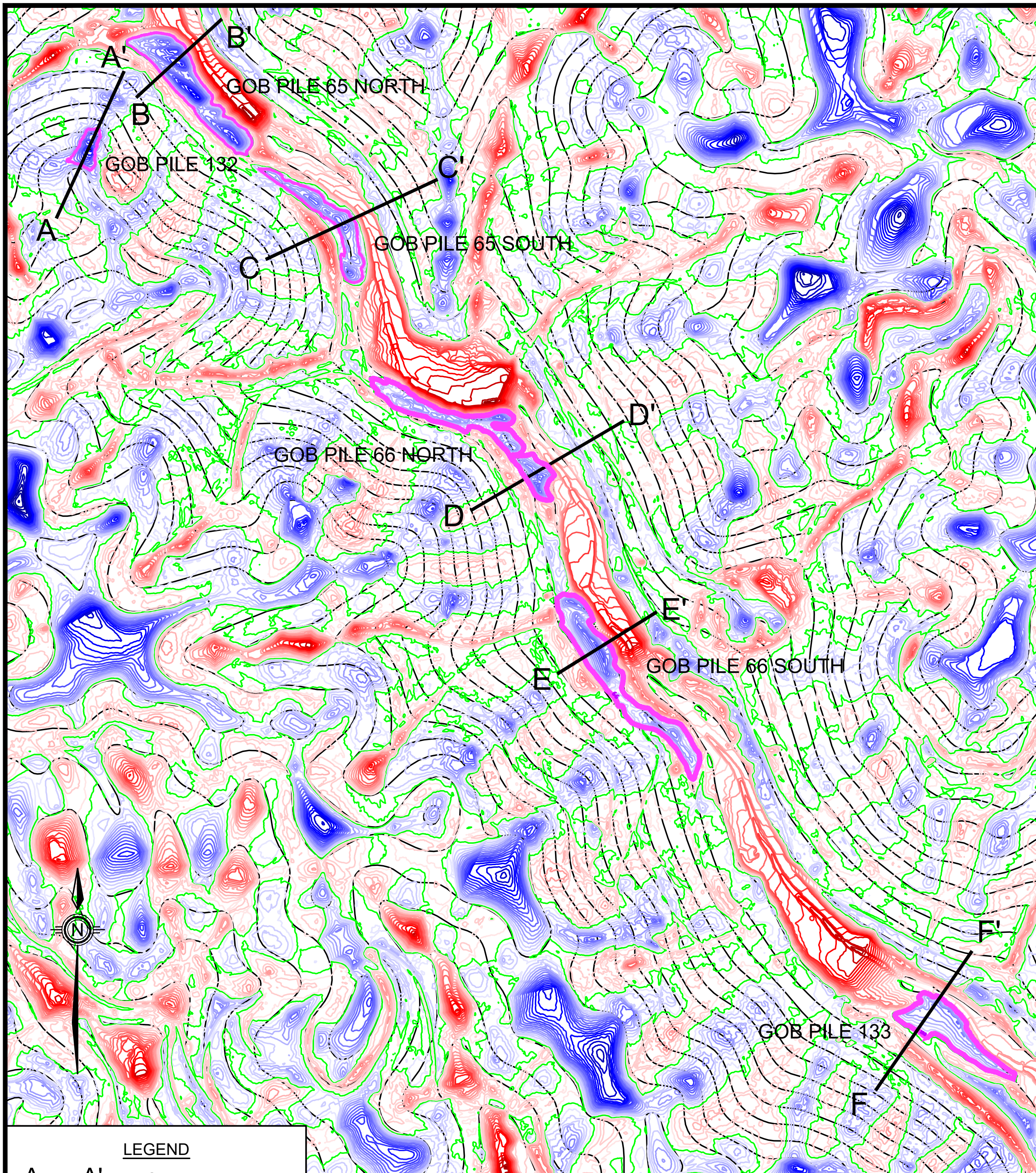
Exhibit 10A
PLANVIEW
GOB PILES 65, 66, 132 AND 133



LEGEND

A—A' PROFILE LINE

ORIGINAL CONTOURS

FILL CONTOURS

CUT CONTOURS

0 600
feet

MARSHALL MILLER & ASSOCIATES ©

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=600'
Project No.:	VAEN100
File No65-66-132-133 CF.DWG	

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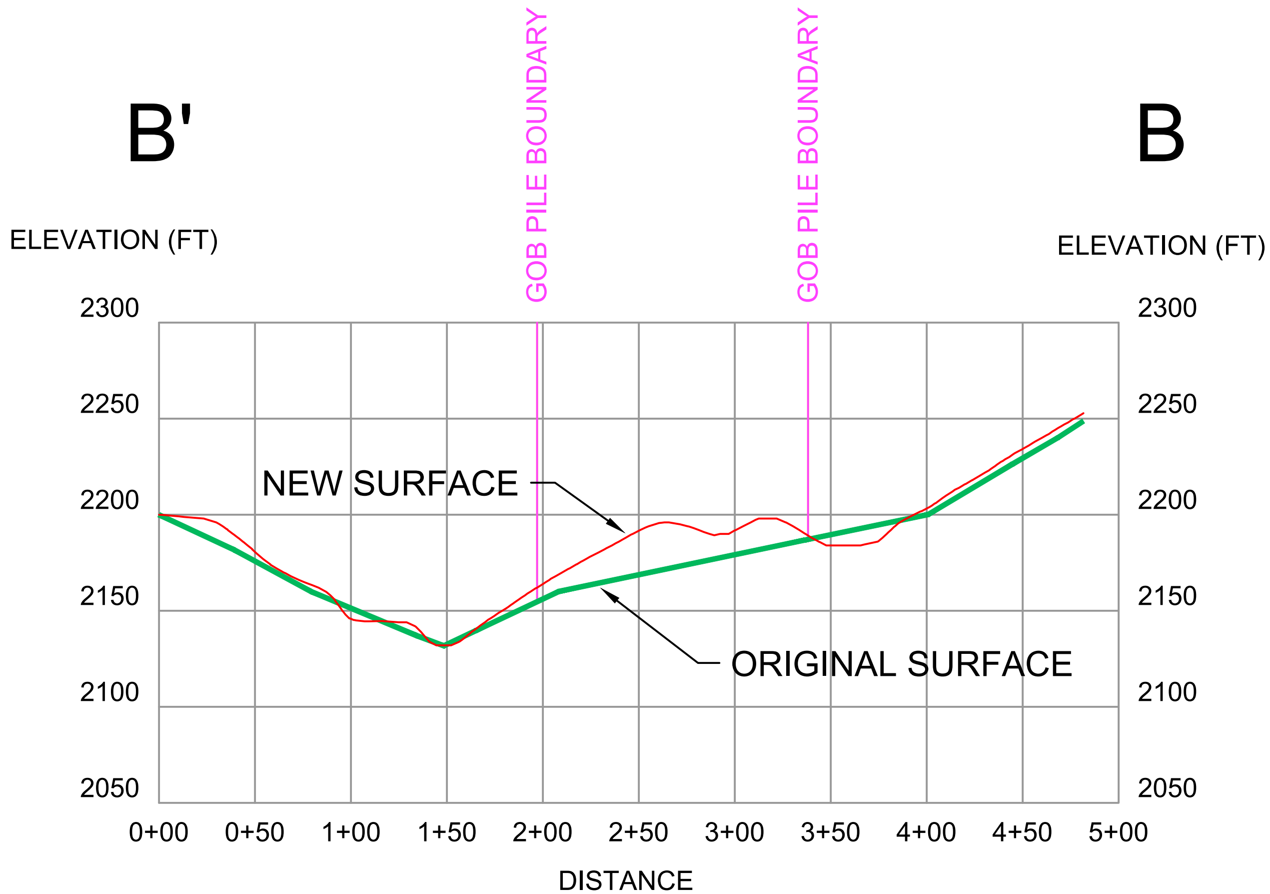
Exhibit 10B
PLANVIEW
GOB PILES 65, 66, 132 AND 133



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Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	65-66-132-133 CF.DWG

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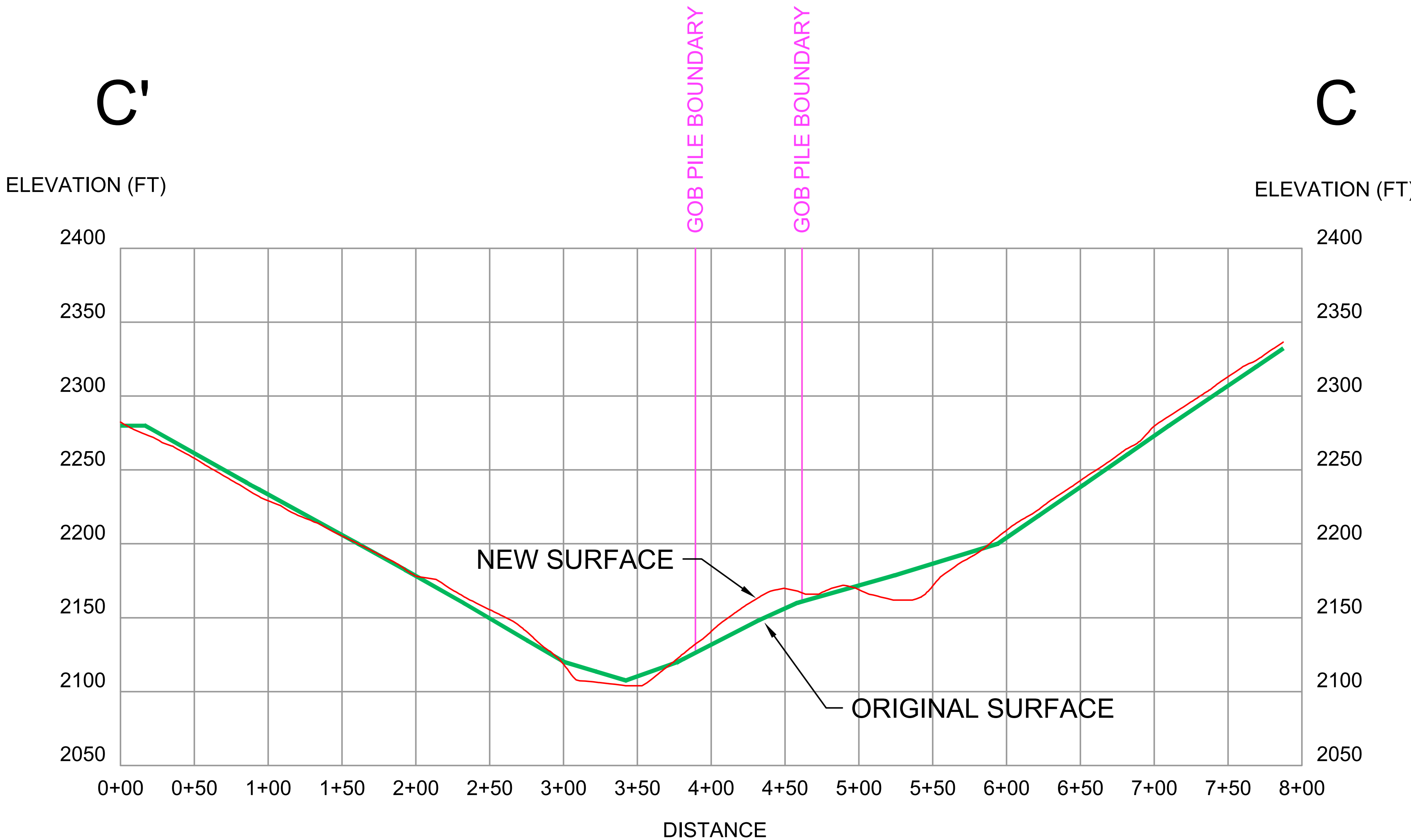
Big Stone Gap, Virginia

Exhibit 10C

GOB PILE 65 NORTH
PROFILE B - B'



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	65-66-132-133 CF.DWG

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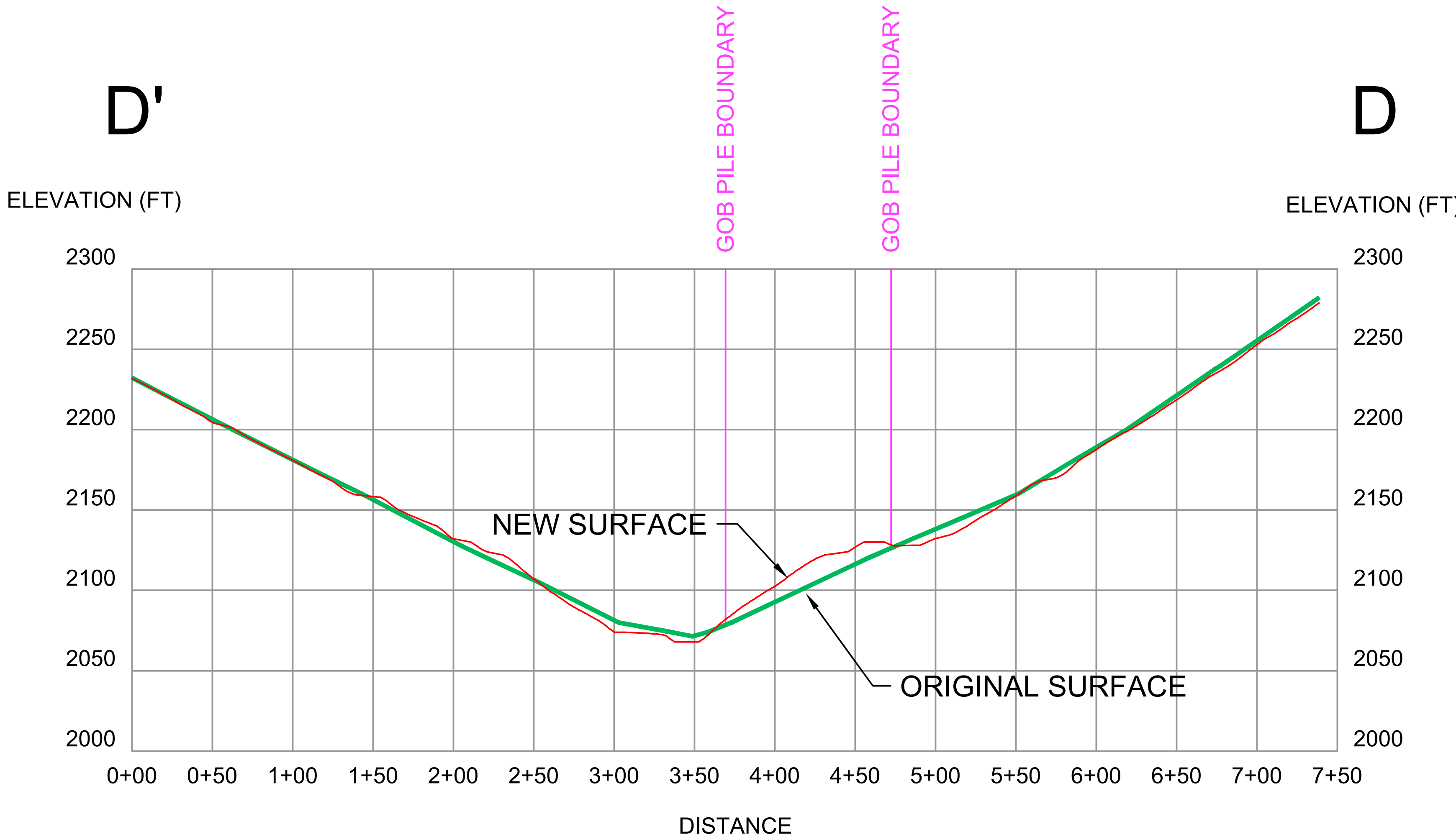
Exhibit 10D

GOB PILE 65 SOUTH
PROFILE C - C'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	65-66-132-133 CF.DWG

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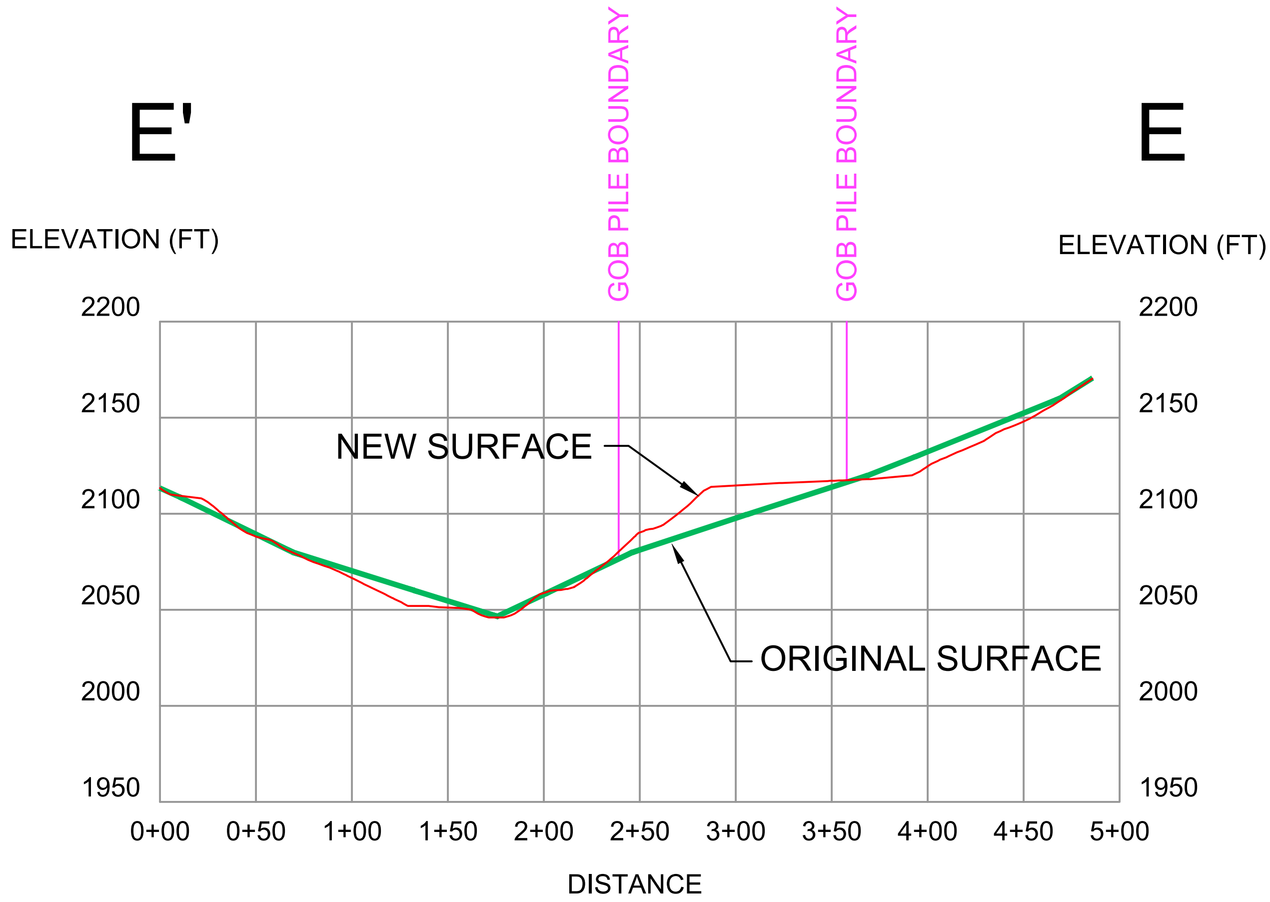
Exhibit 10E

GOB PILE 66 NORTH
PROFILE D - D'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
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Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	65-66-132-133 CF.DWG

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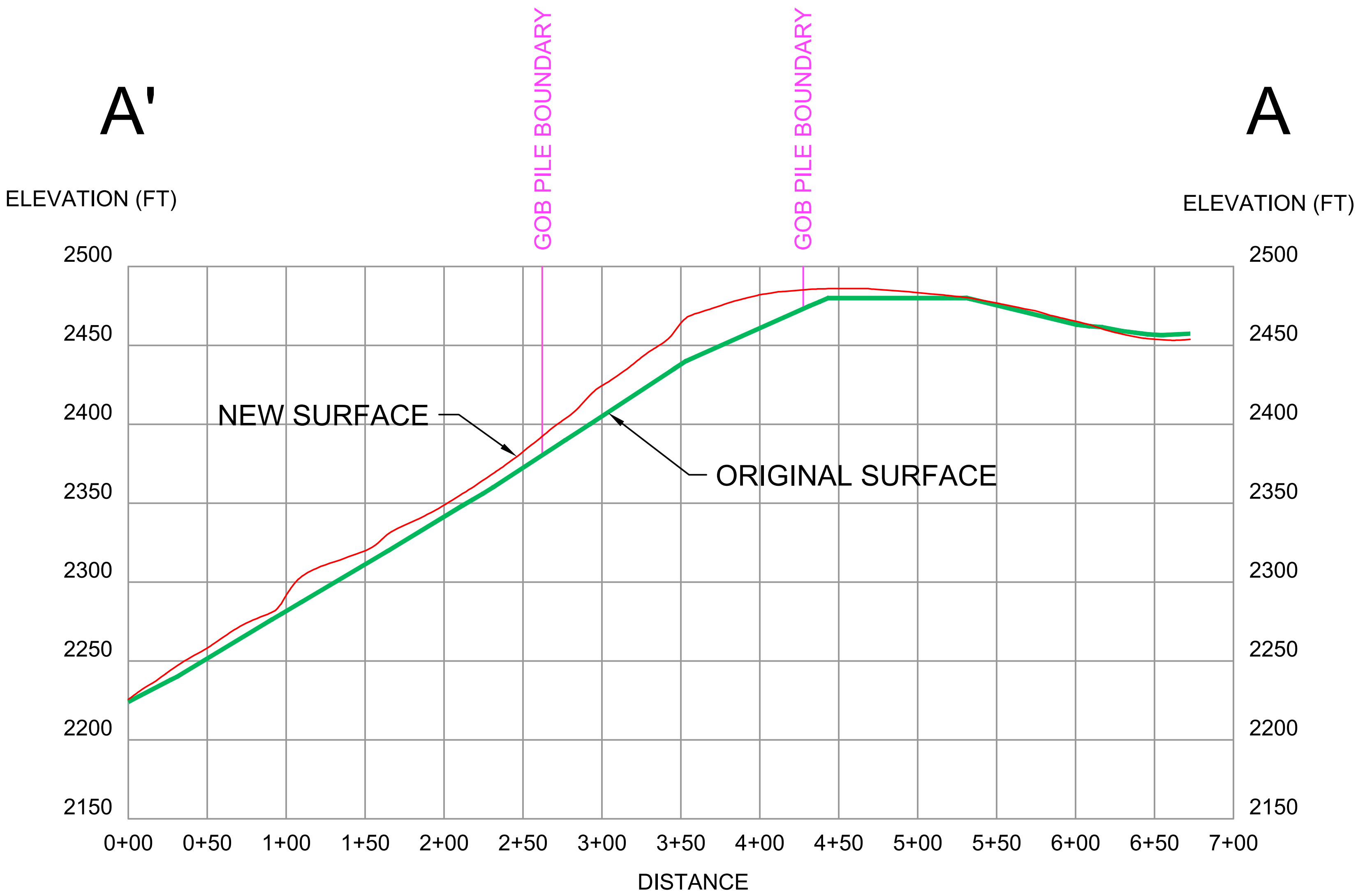
Exhibit 10F

GOB PILE 66 NORTH
PROFILE E - E'



Drawn:	SA
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Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	65-66-132-133 CF.DWG

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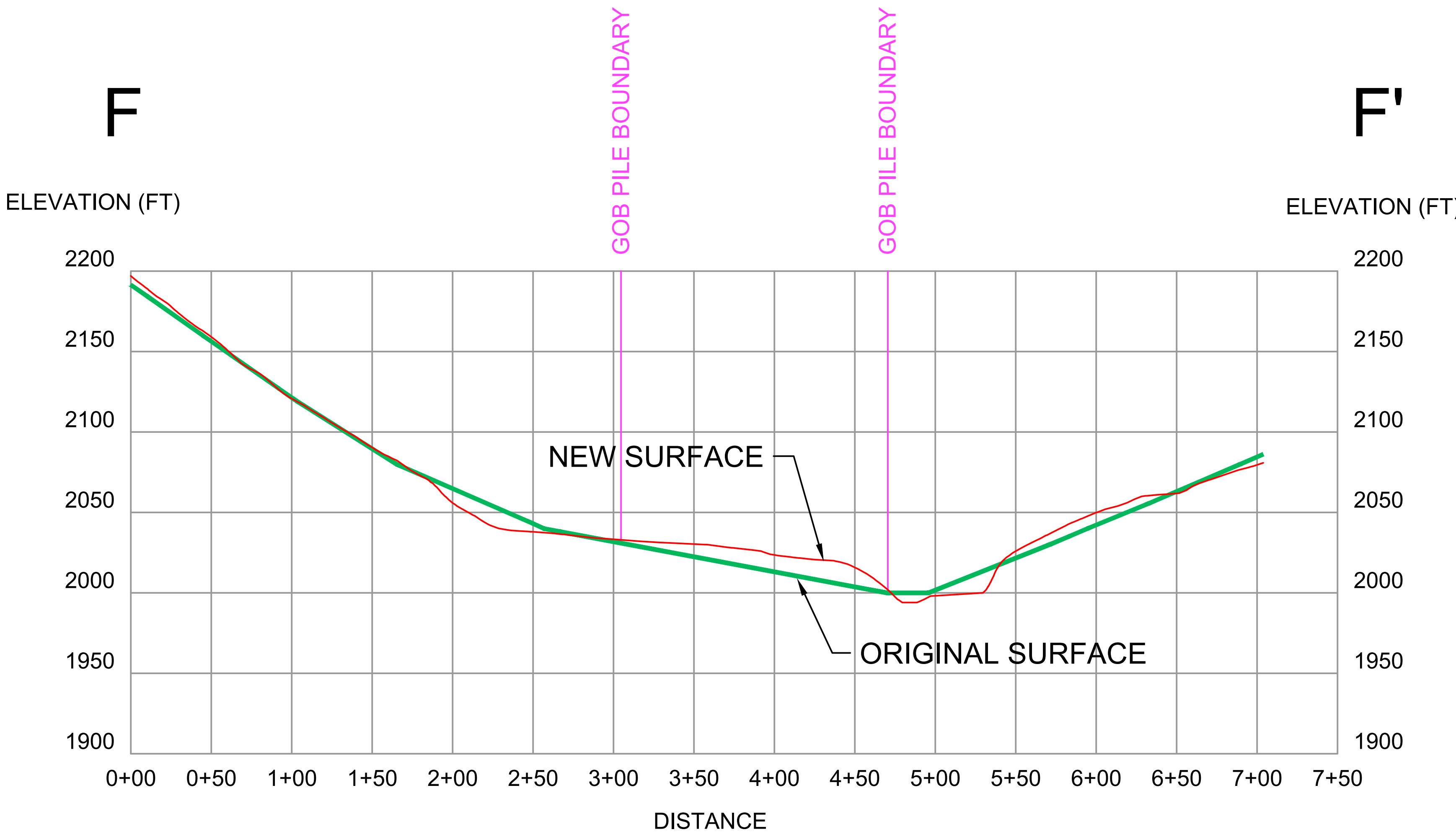
Exhibit 10G

GOB PILE 132
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	65-66-132-133 CF.DWG

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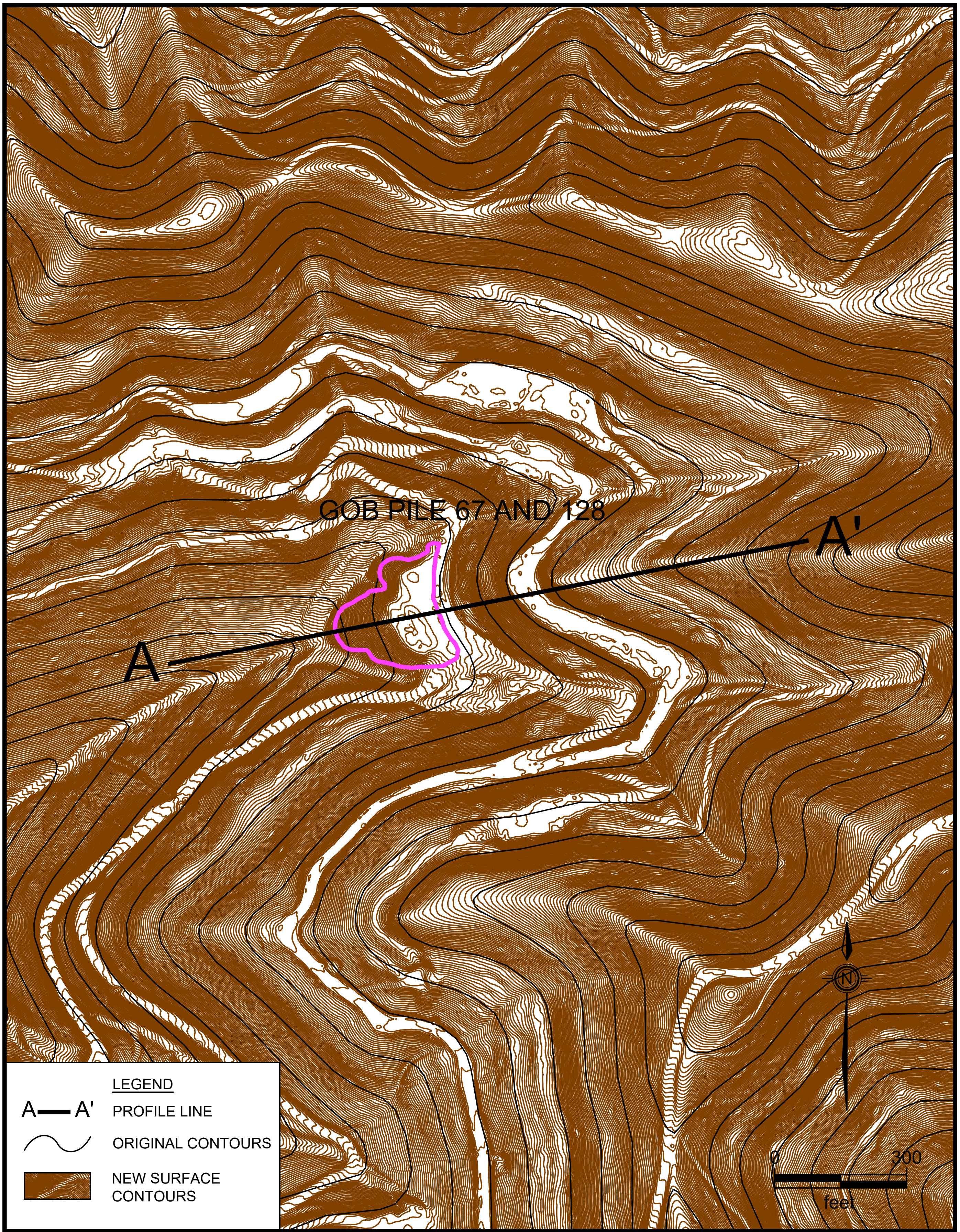
Exhibit 10H

GOB PILE 133 SOUTH
PROFILE F - F'



MARSHALL MILLER & ASSOCIATES

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Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	67 128 CF.DWG

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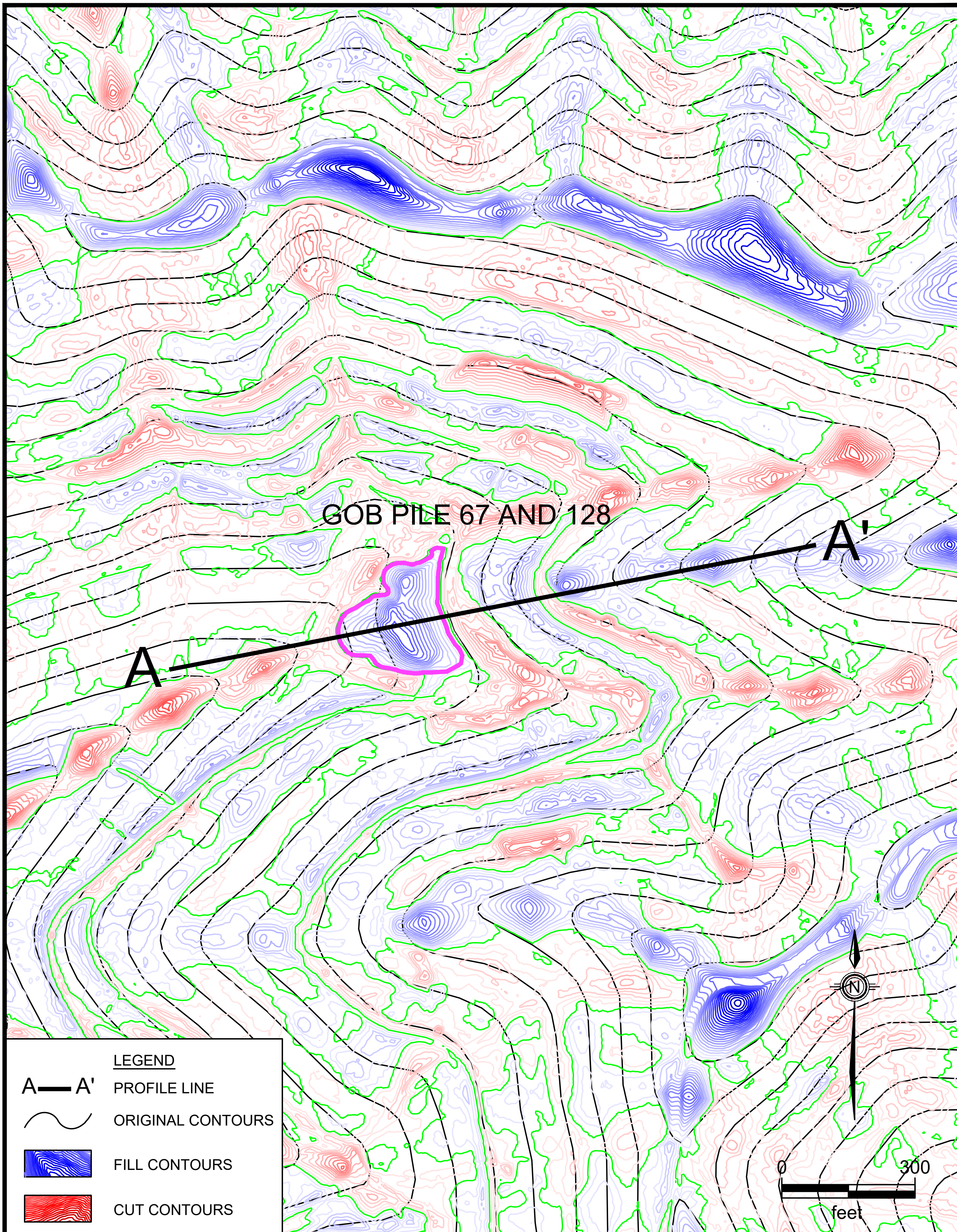
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 11A
PLANVIEW
GOB PILE 67 AND 128



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	67 128 CF.DWG

Virginia Department Of Energy
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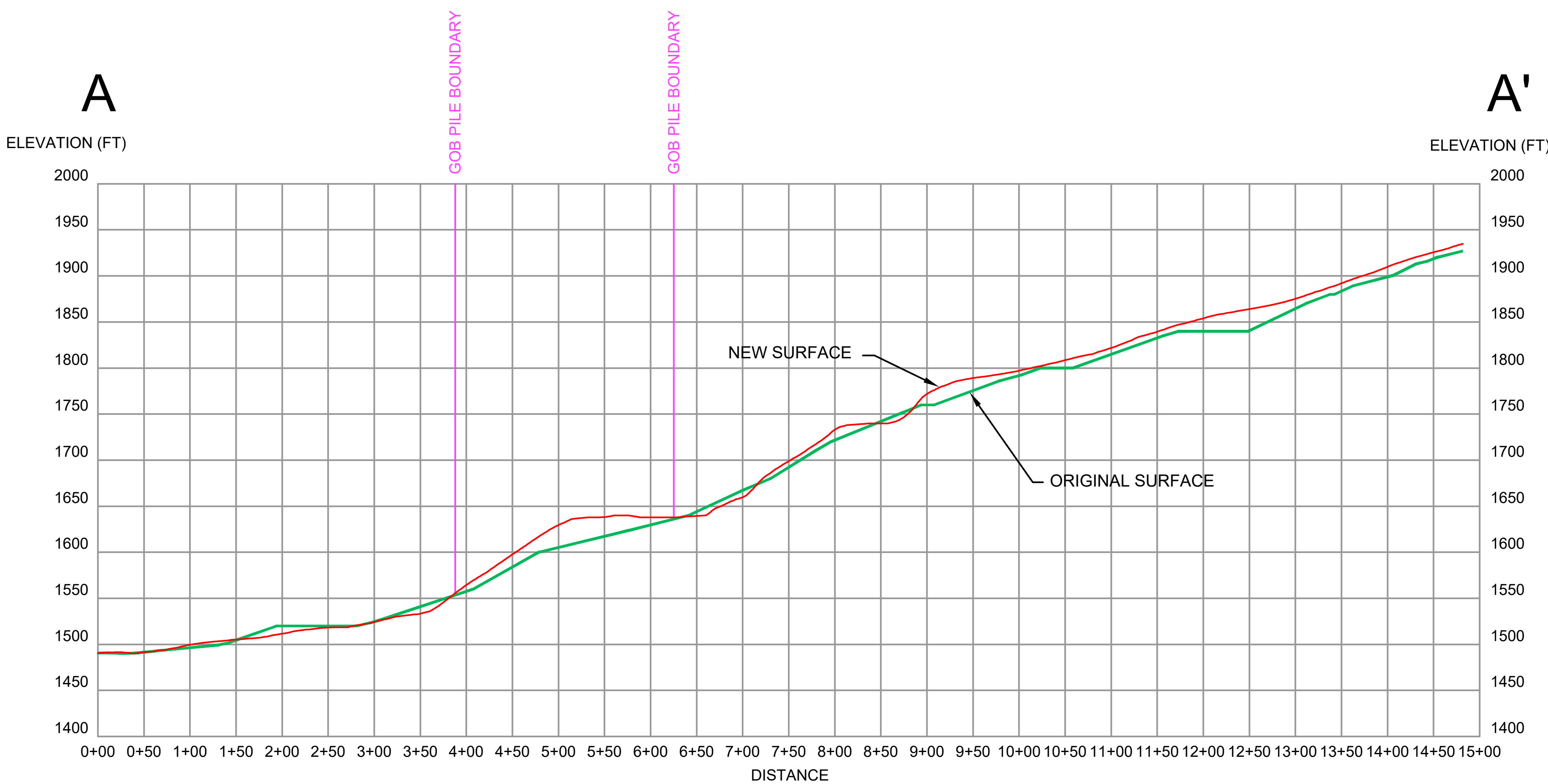
Exhibit 11B

PLANVIEW
GOB PILE 67 AND 128



MARSHALL MILLER & ASSOCIATES®

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	67 128 CF.DWG

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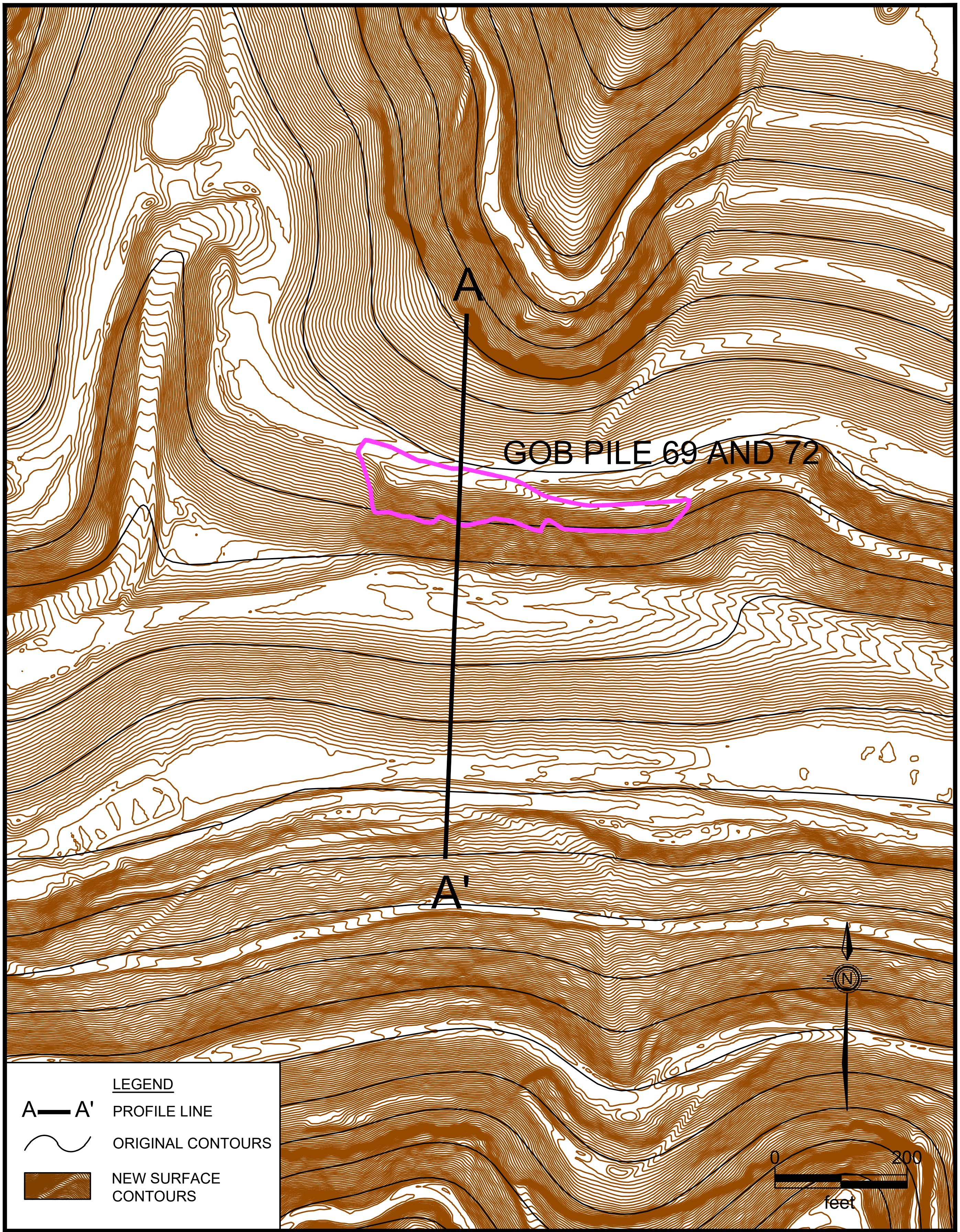
Big Stone Gap, Virginia

Exhibit 11C

GOB PILE 67 AND 128
PROFILE A - A'



Drawn:	SA	
Checked:	SA	
Date:	9/2022	
Scale:	1"=200'	
Project No.:	VAEN100	
File No.	69 72 CF.DWG	

Virginia Department Of Energy
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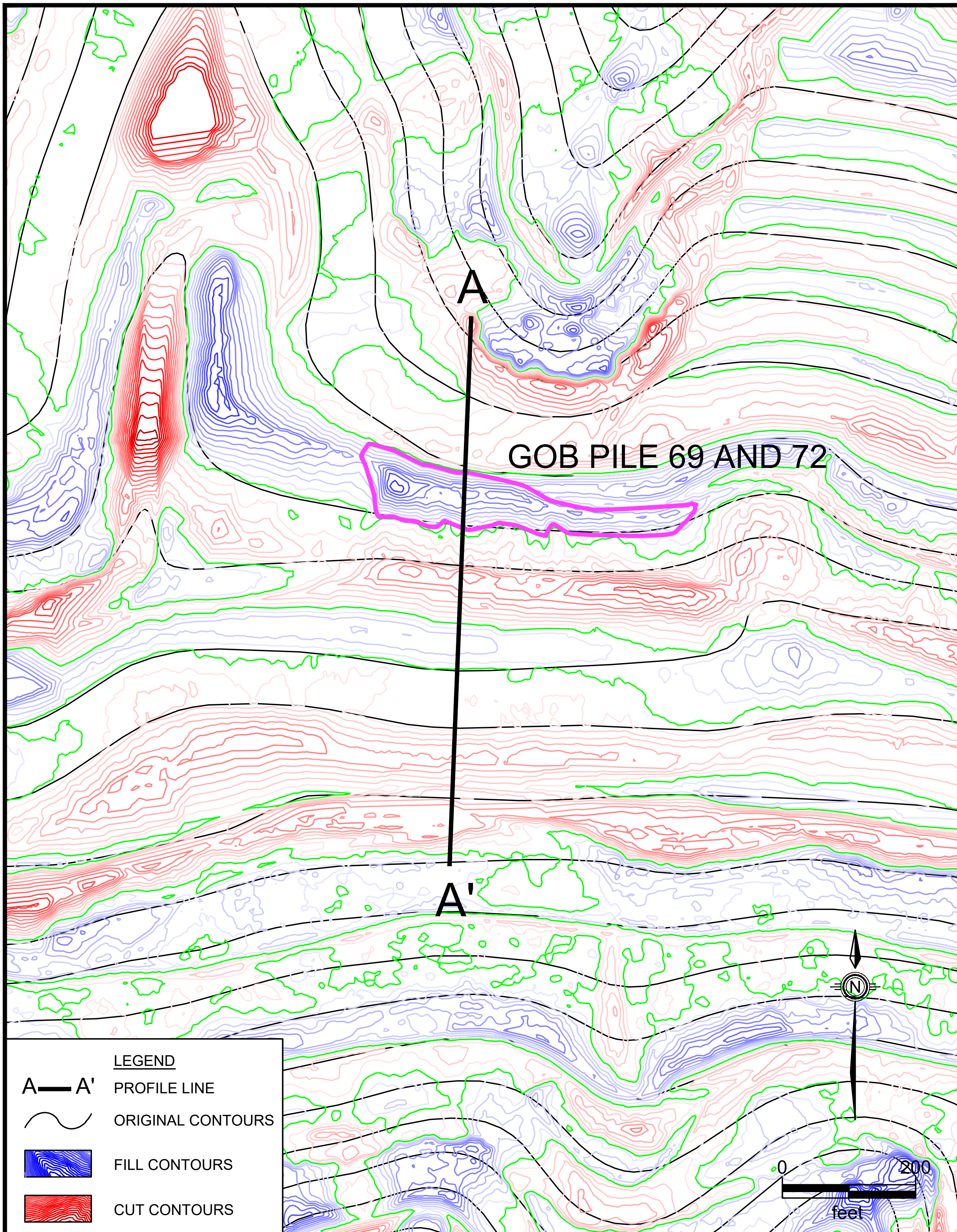
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 12A
PLANVIEW
GOB PILE 69 AND 72



MARSHALL MILLER & ASSOCIATES©

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	69-72 CF.DWG

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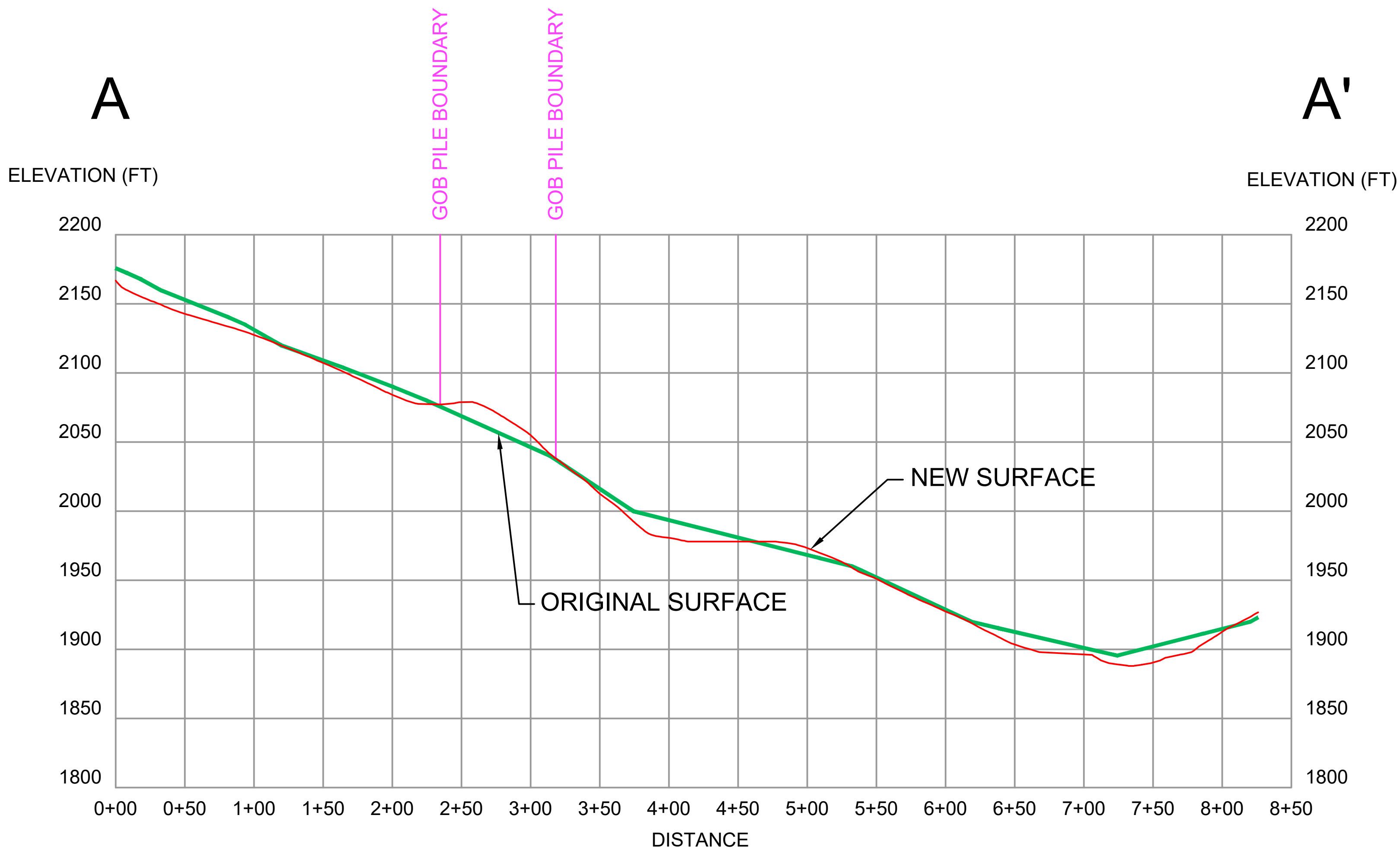
Big Stone Gap, Virginia

Exhibit 12B
PLANVIEW
GOB PILE 69 AND 72



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	69-72 CF.DWG

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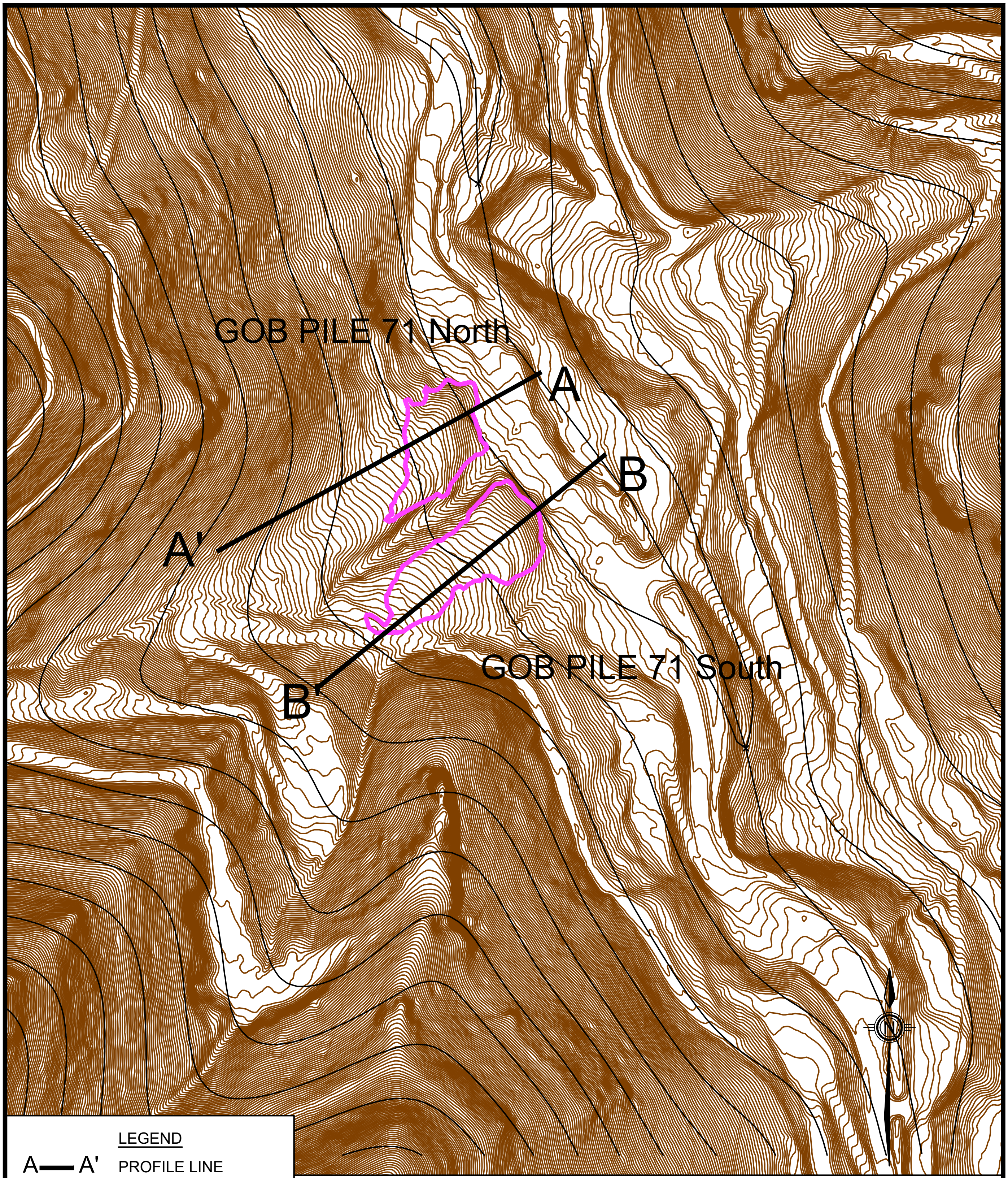
Exhibit 12C

GOB PILE 69 AND 72
PROFILE A - A'



LEGEND

A—A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

0 200
feet

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	71 CF.DWG

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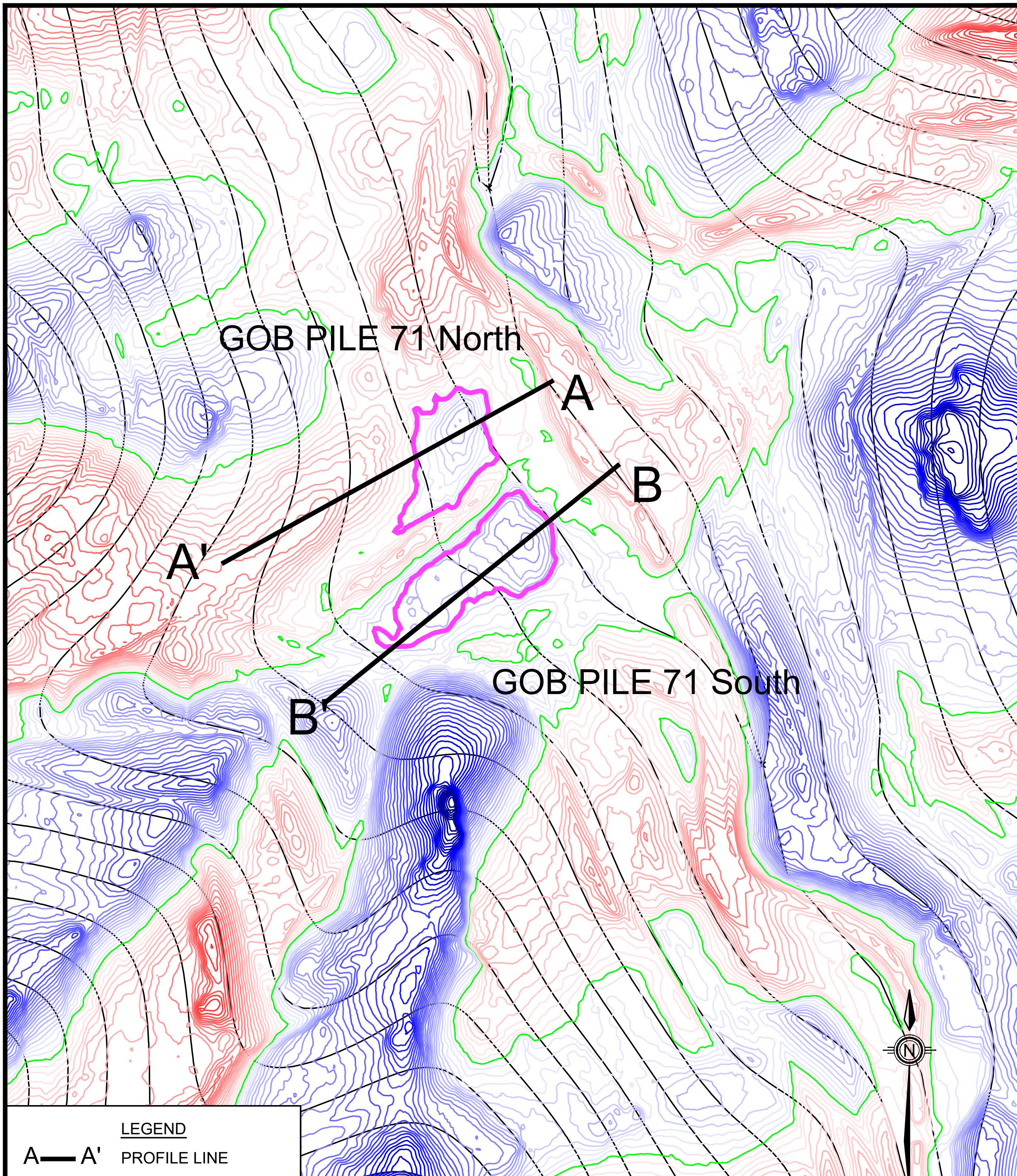
Exhibit 13A
PLANVIEW
GOB PILE 71



LEGEND

A—A' PROFILE LINE

ORIGINAL CONTOURS

FILL CONTOURS

CUT CONTOURS

0 200
feet

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	71 CF.DWG

Virginia Department Of Energy
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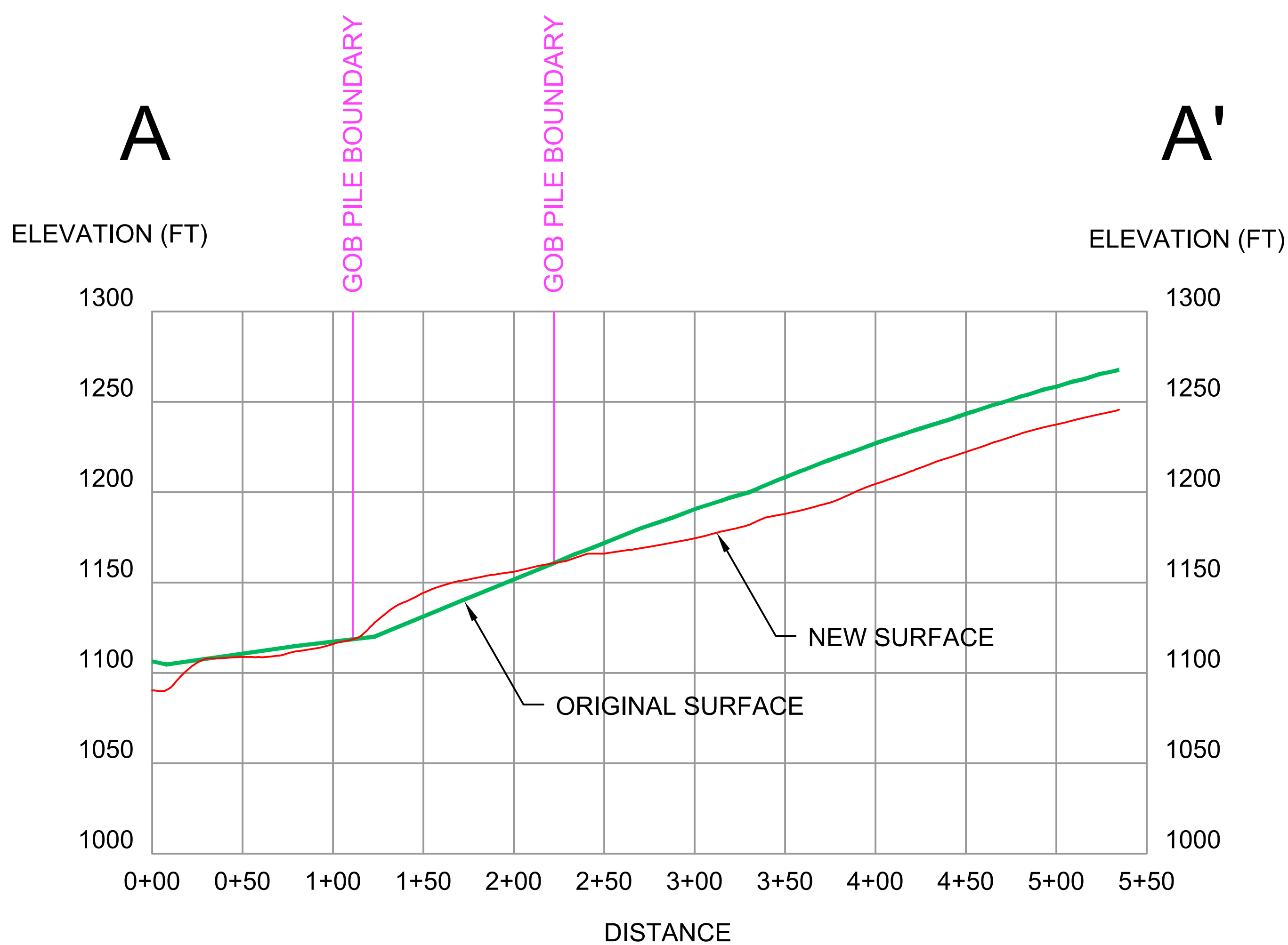
Exhibit 13B
PLANVIEW
GOB PILE 71



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
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Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	71 CF.DWG

Virginia Department Of Energy
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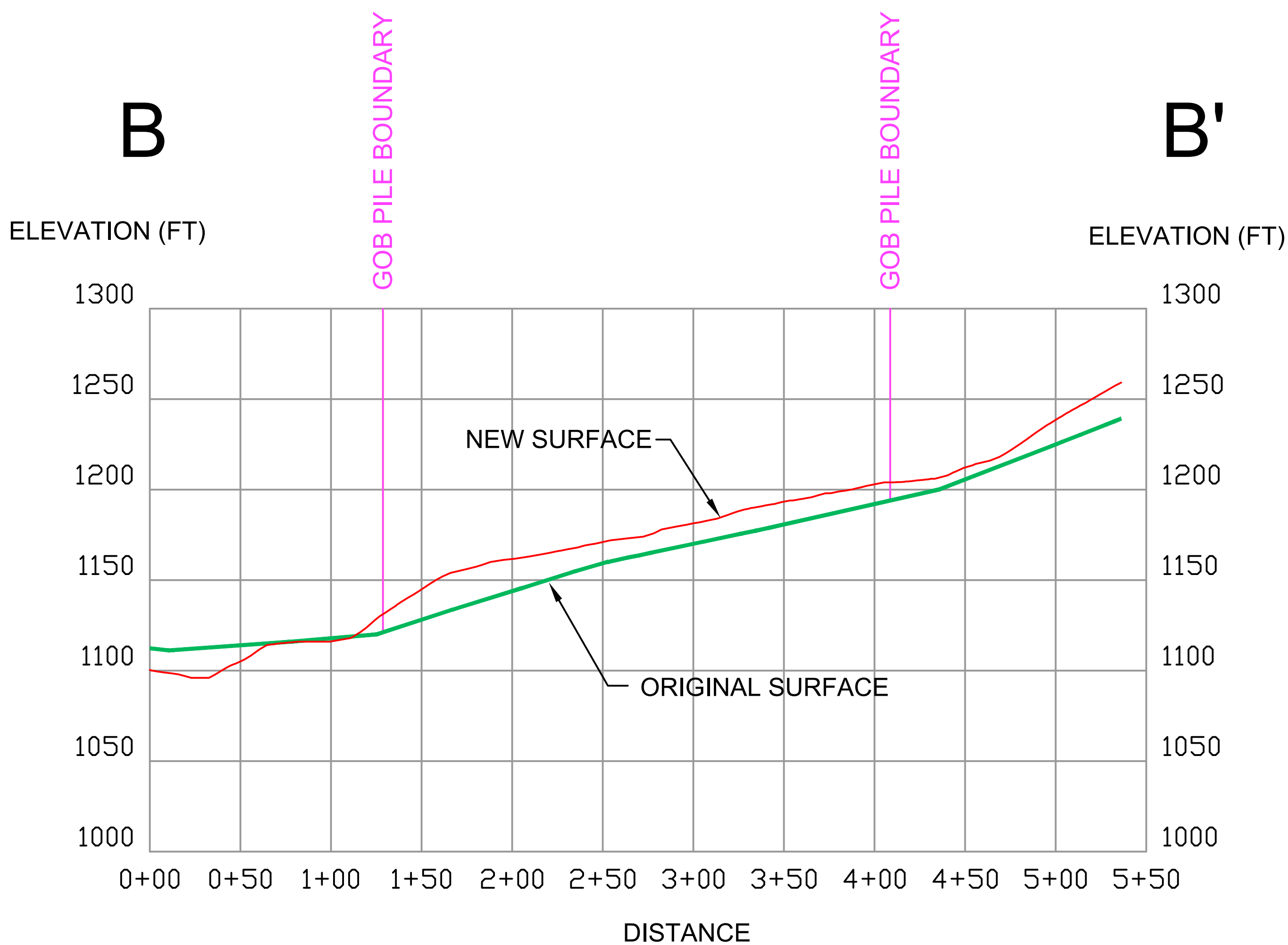
Exhibit 13C

GOB PILE 71 NORTH
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	71 CF.DWG

Virginia Department Of Energy
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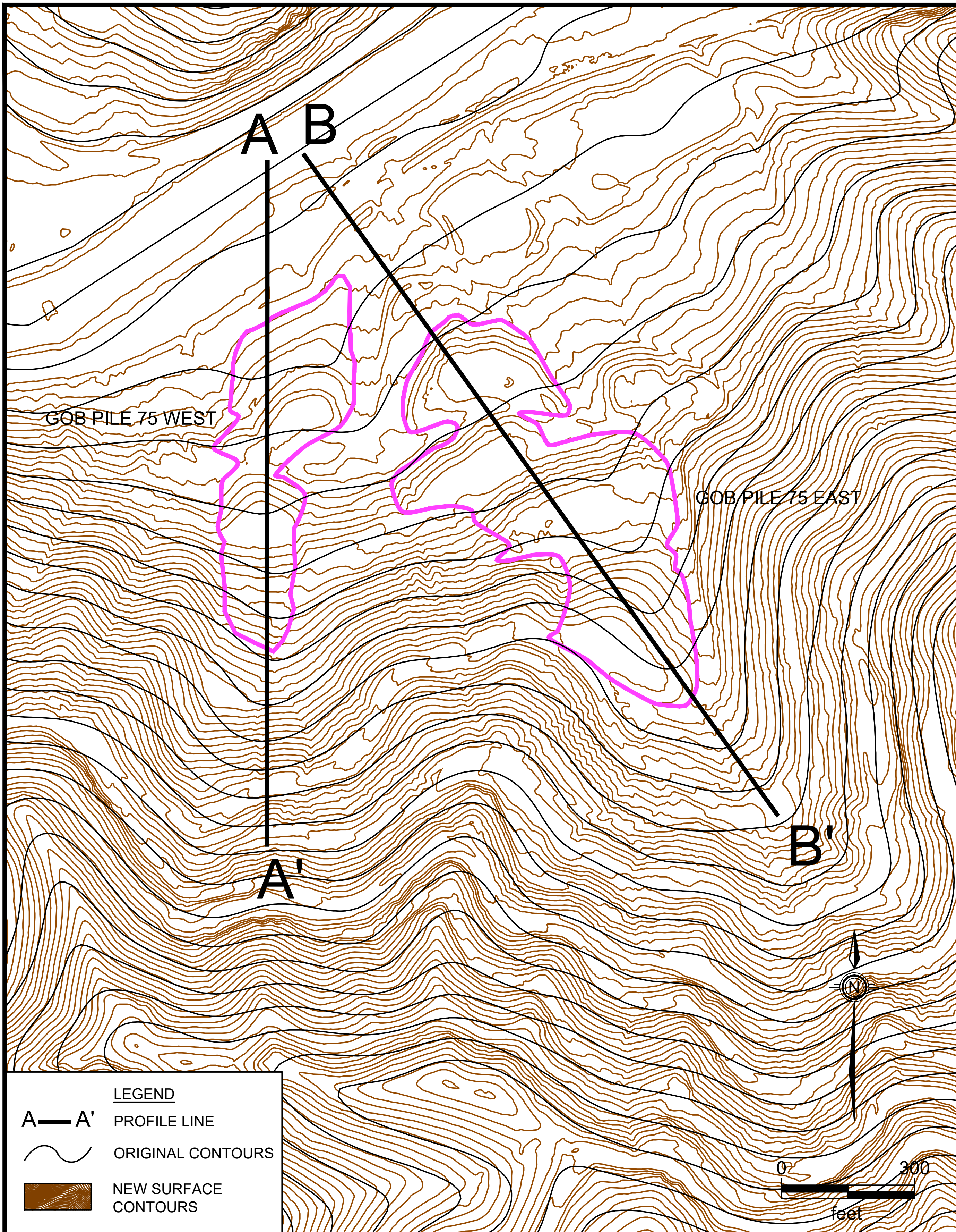
Big Stone Gap, Virginia

Exhibit 13D

GOB PILE 71 SOUTH
PROFILE B - B'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	75 CF.DWG

Virginia Department Of Energy
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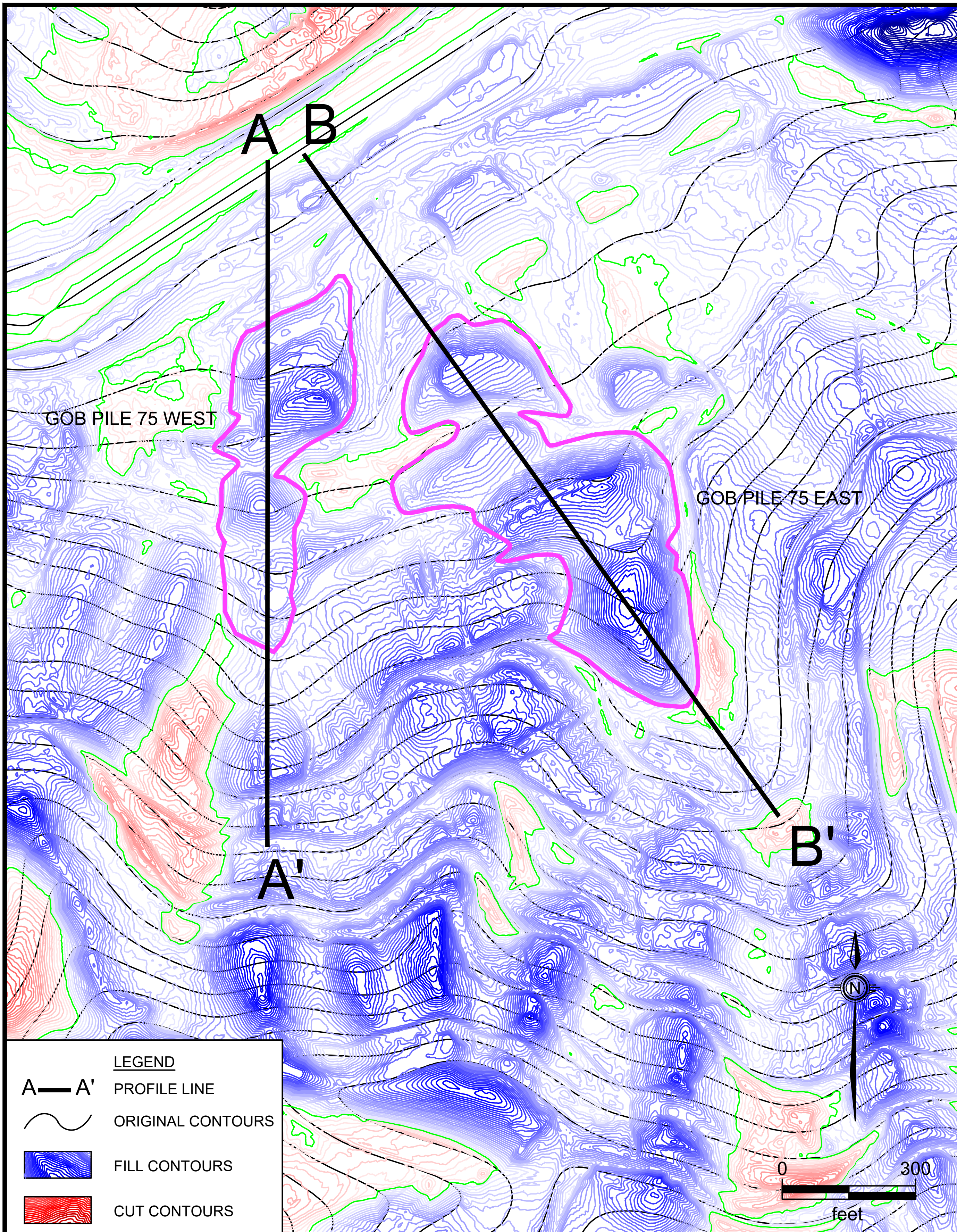
Big Stone Gap, Virginia

Exhibit 14A
PLANVIEW
GOB PILE 75



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	75 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
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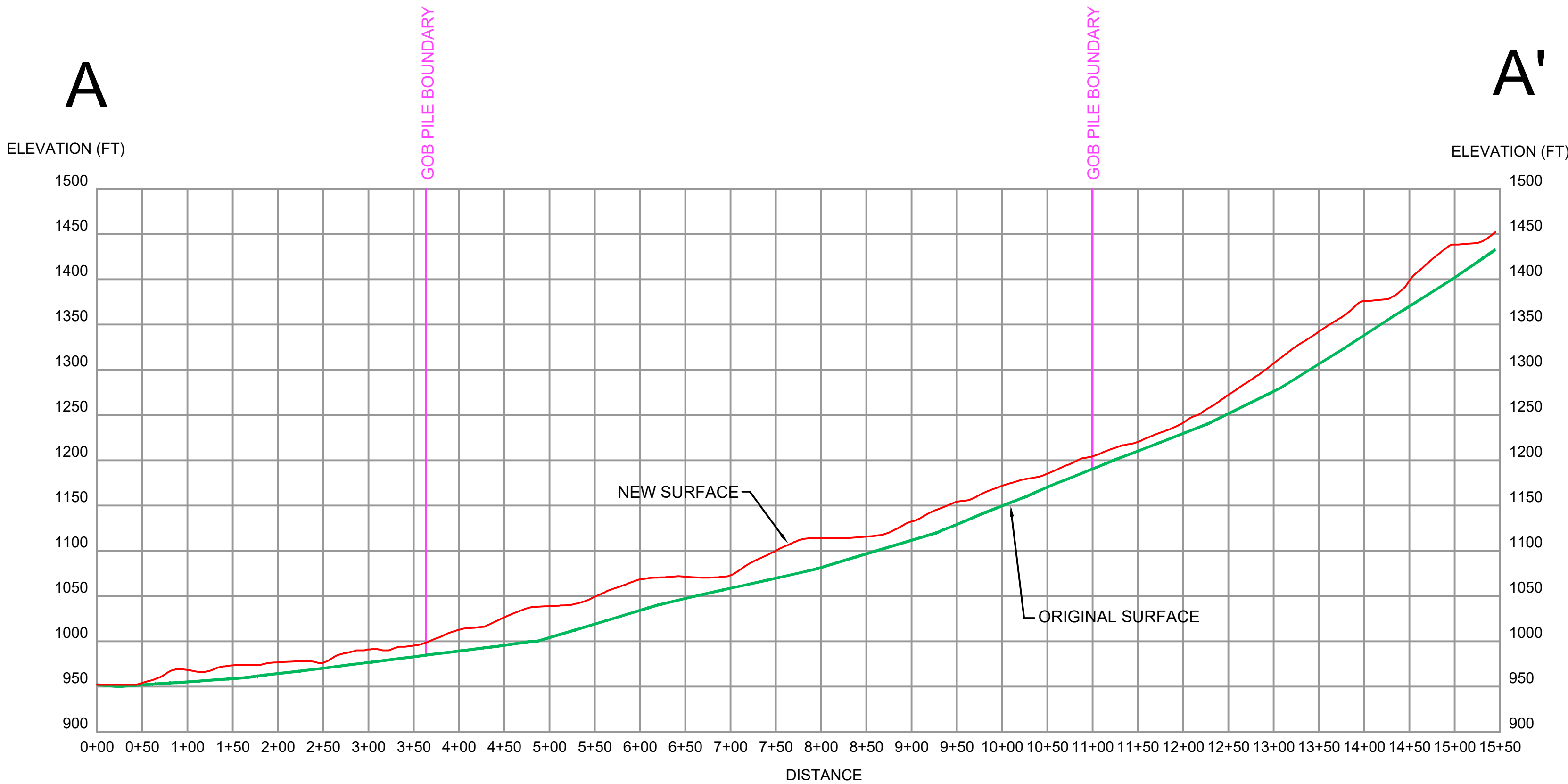
Big Stone Gap, Virginia

Exhibit 14B
PLANVIEW
GOB PILE 75



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	75 CF.DWG

Virginia Department Of Energy
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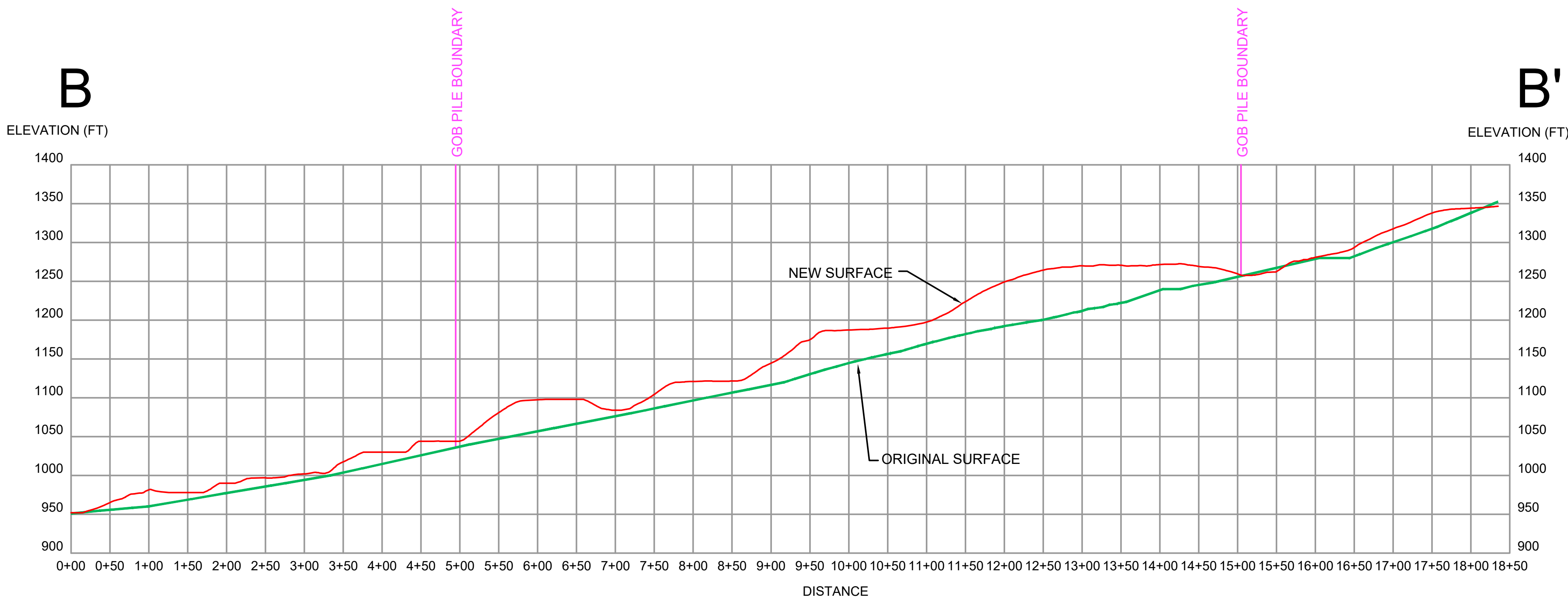
Exhibit 14C

GOB PILE 75 WEST
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	75 CF.DWG

Virginia Department Of Energy
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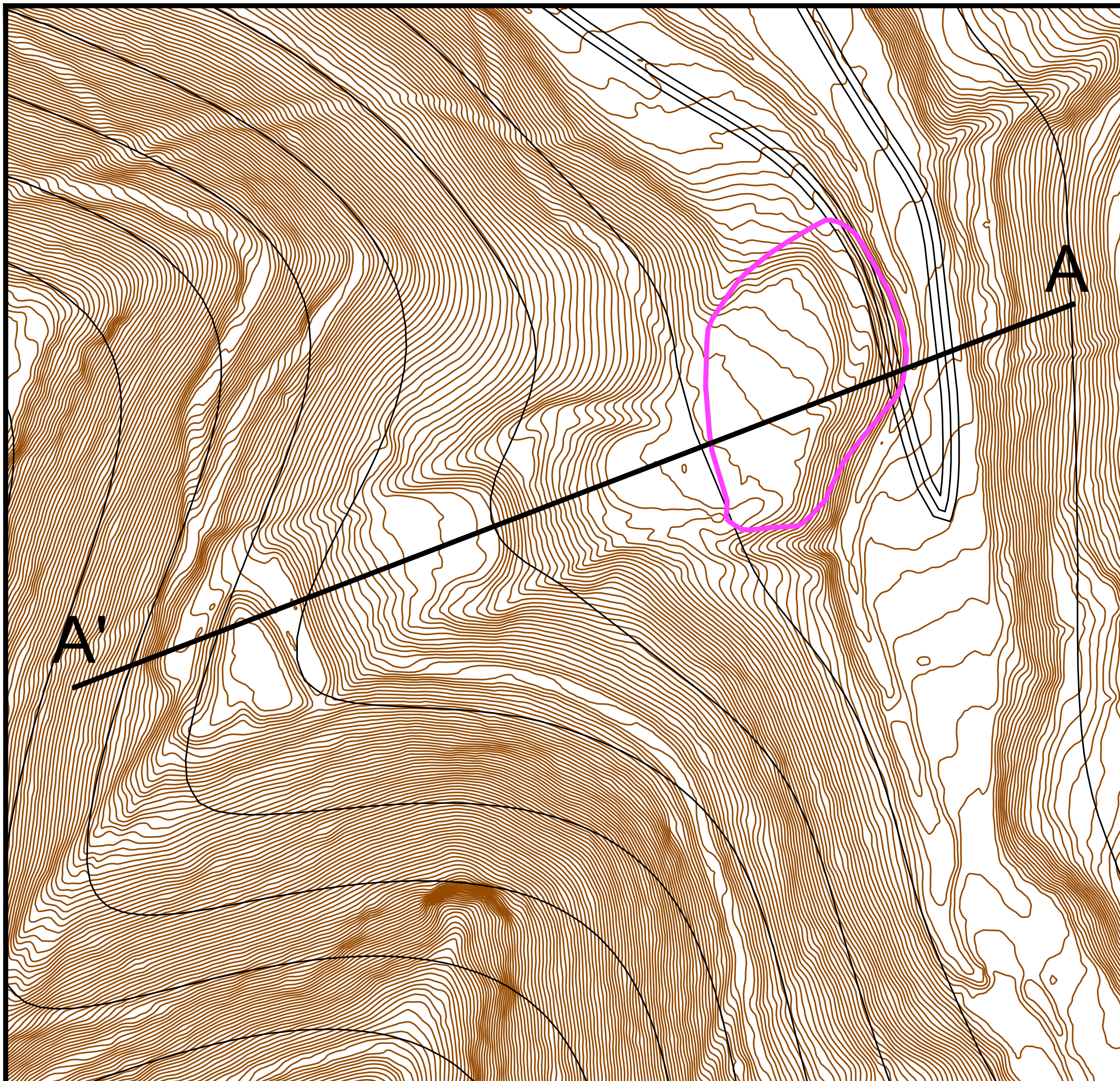
Big Stone Gap, Virginia

Exhibit 14D

GOB PILE 75 EAST
PROFILE B - B'



LEGEND

A — A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

N

0 125

feet

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=125'
Project No.:	VAEN100
File No.	76 CF.DWG

MARSHALL MILLER & ASSOCIATES

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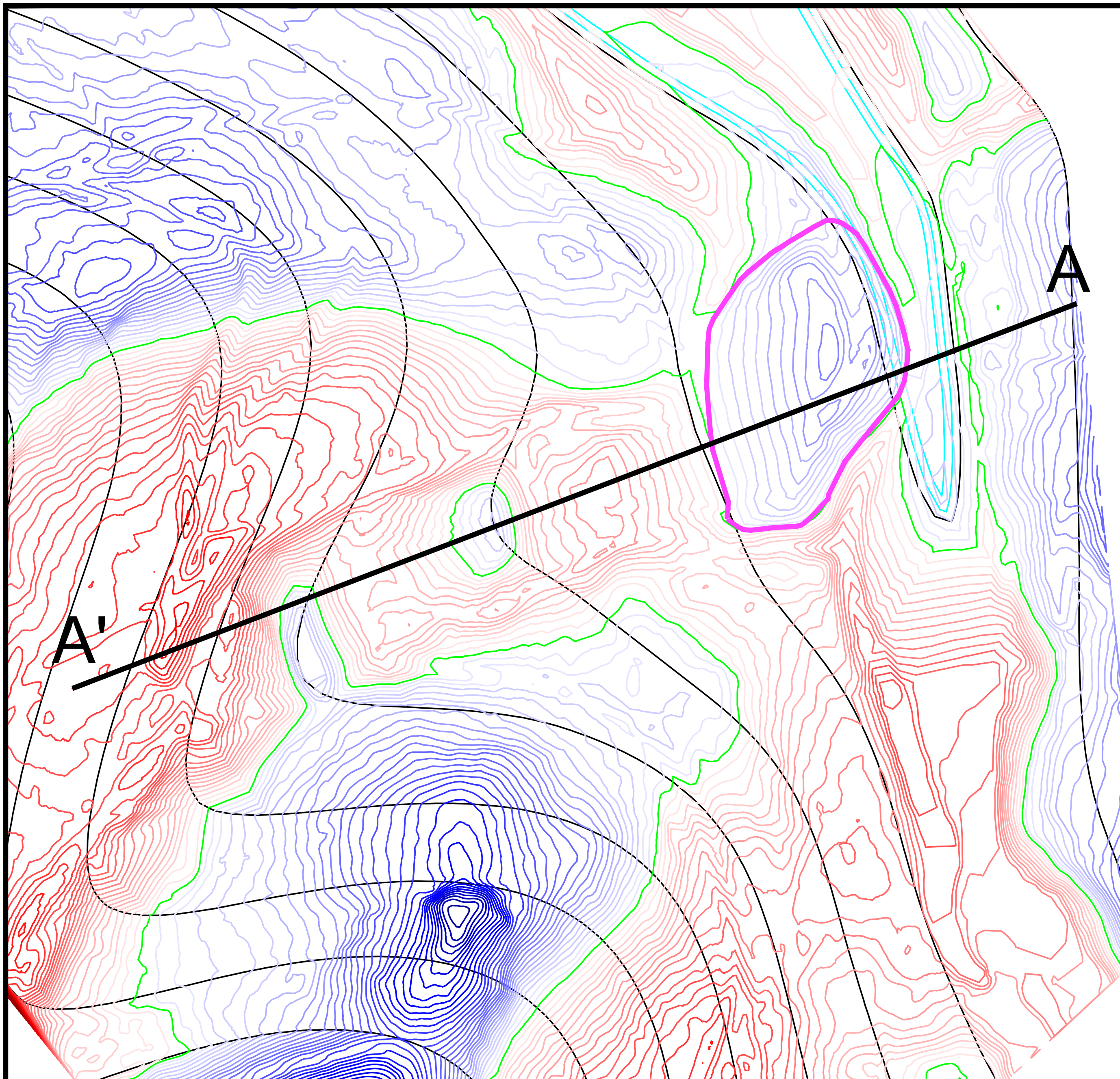
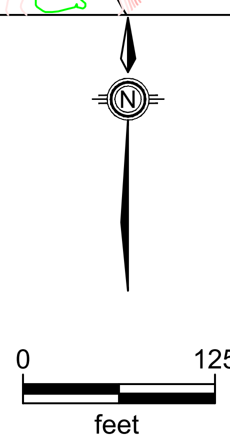
Big Stone Gap, Virginia

Exhibit 15A
PLANVIEW
GOB PILE 76





LEGEND

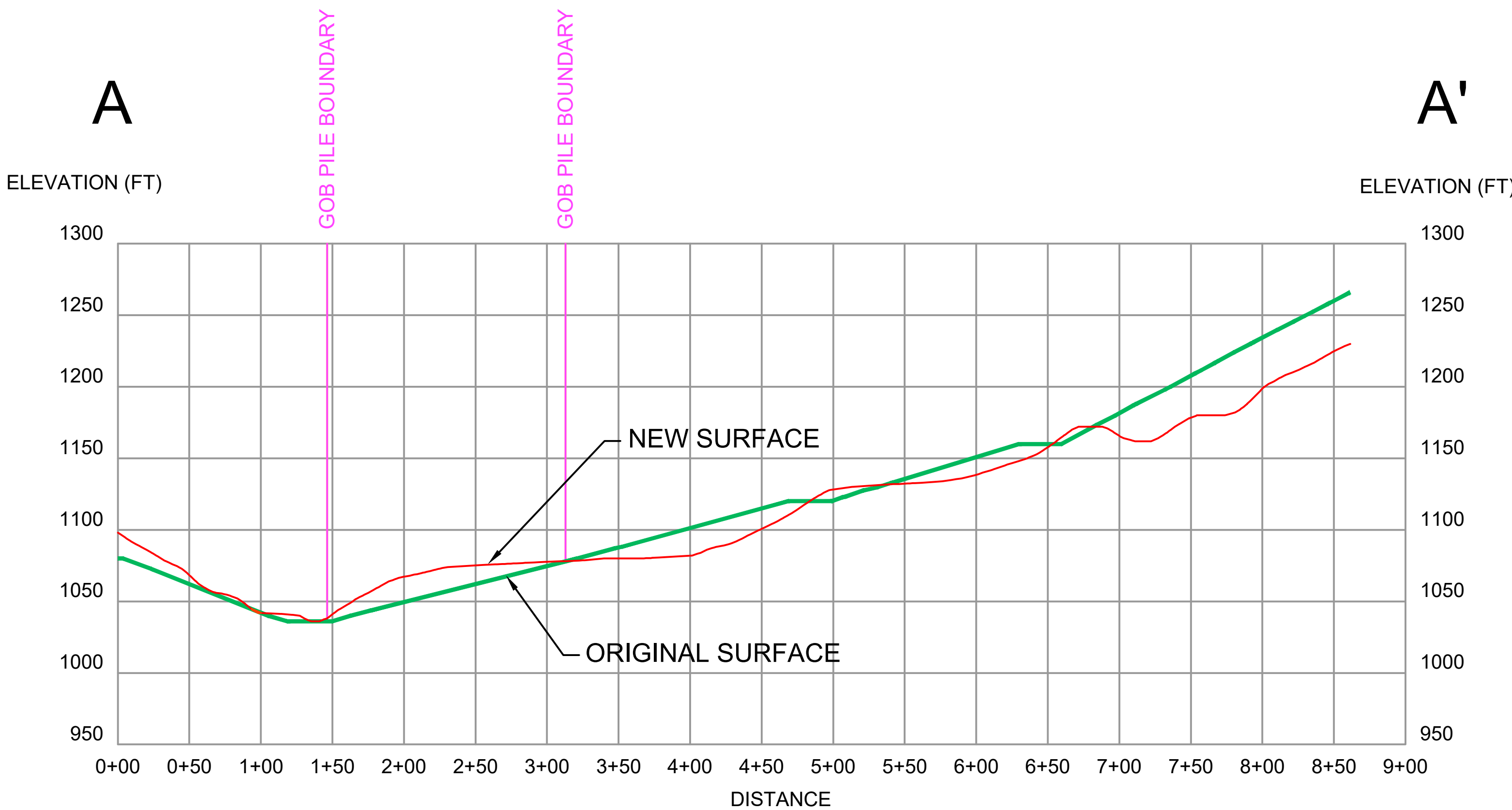
A — A'	PROFILE LINE
	ORIGINAL CONTOURS
	FILL CONTOURS
	CUT CONTOURS

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=125'
Project No.:	VAEN100
File No.	76 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 15B
PLANVIEW
GOB PILE 76



MARSHALL MILLER & ASSOCIATES

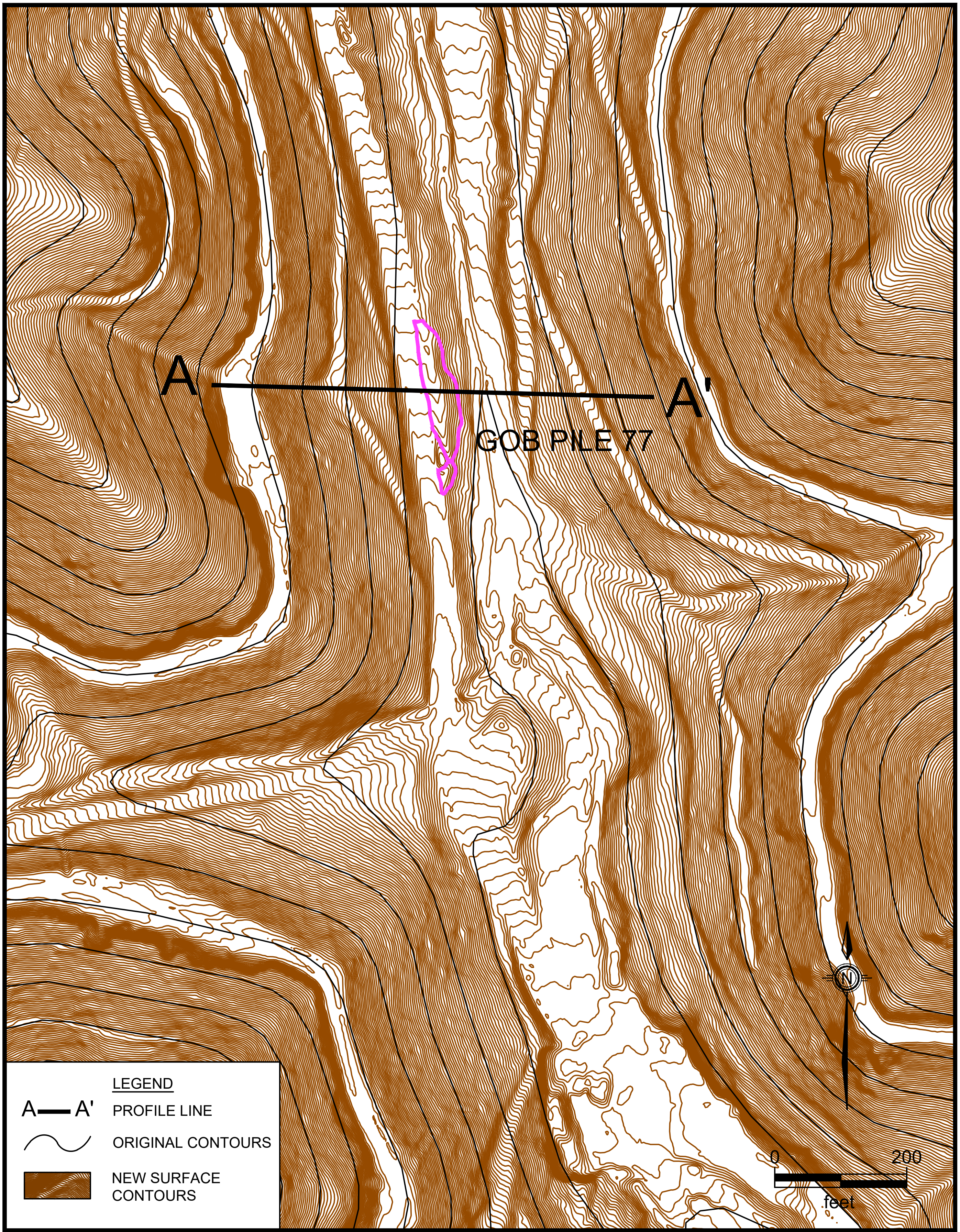
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	76 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

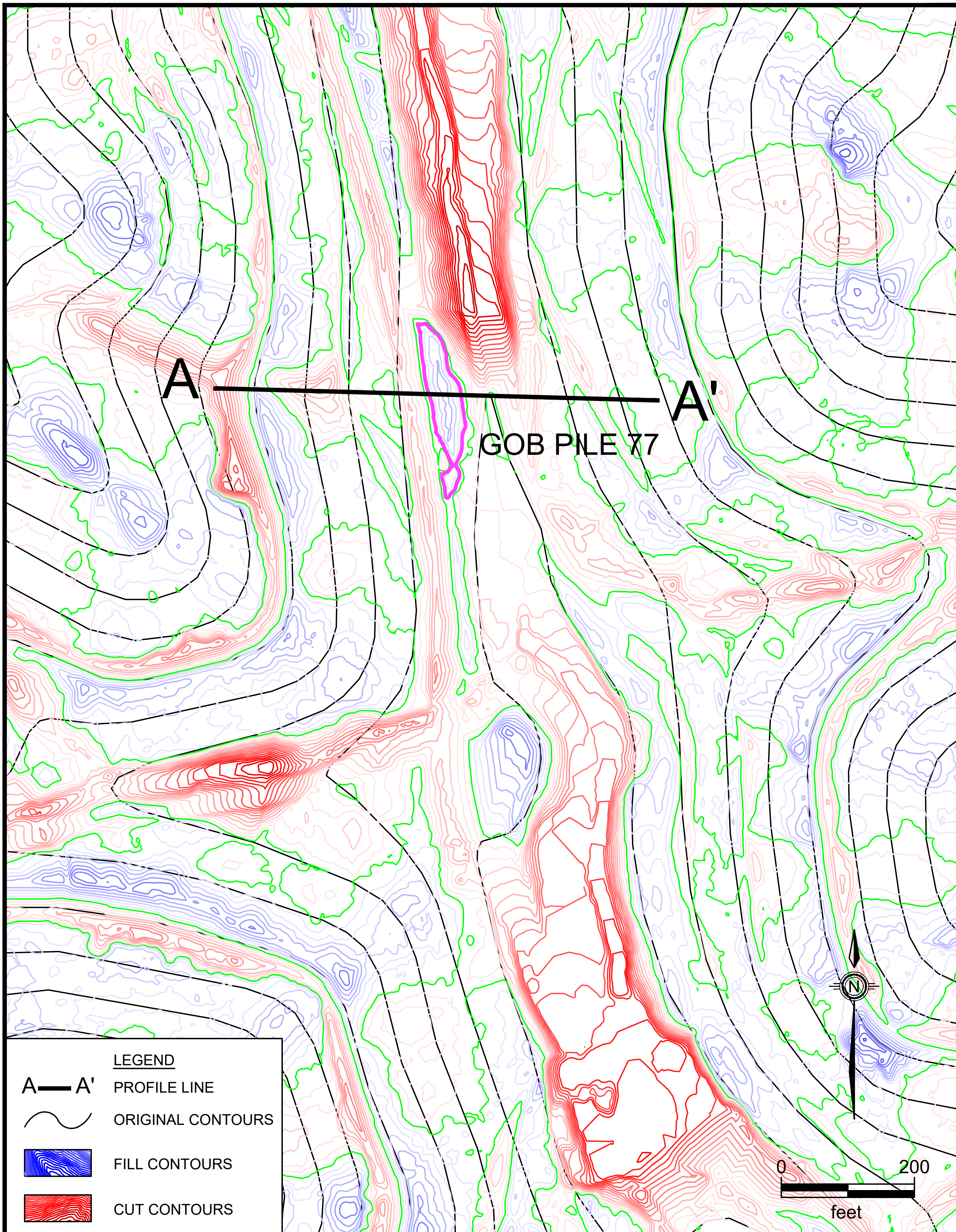
Big Stone Gap, Virginia

Exhibit 15 C

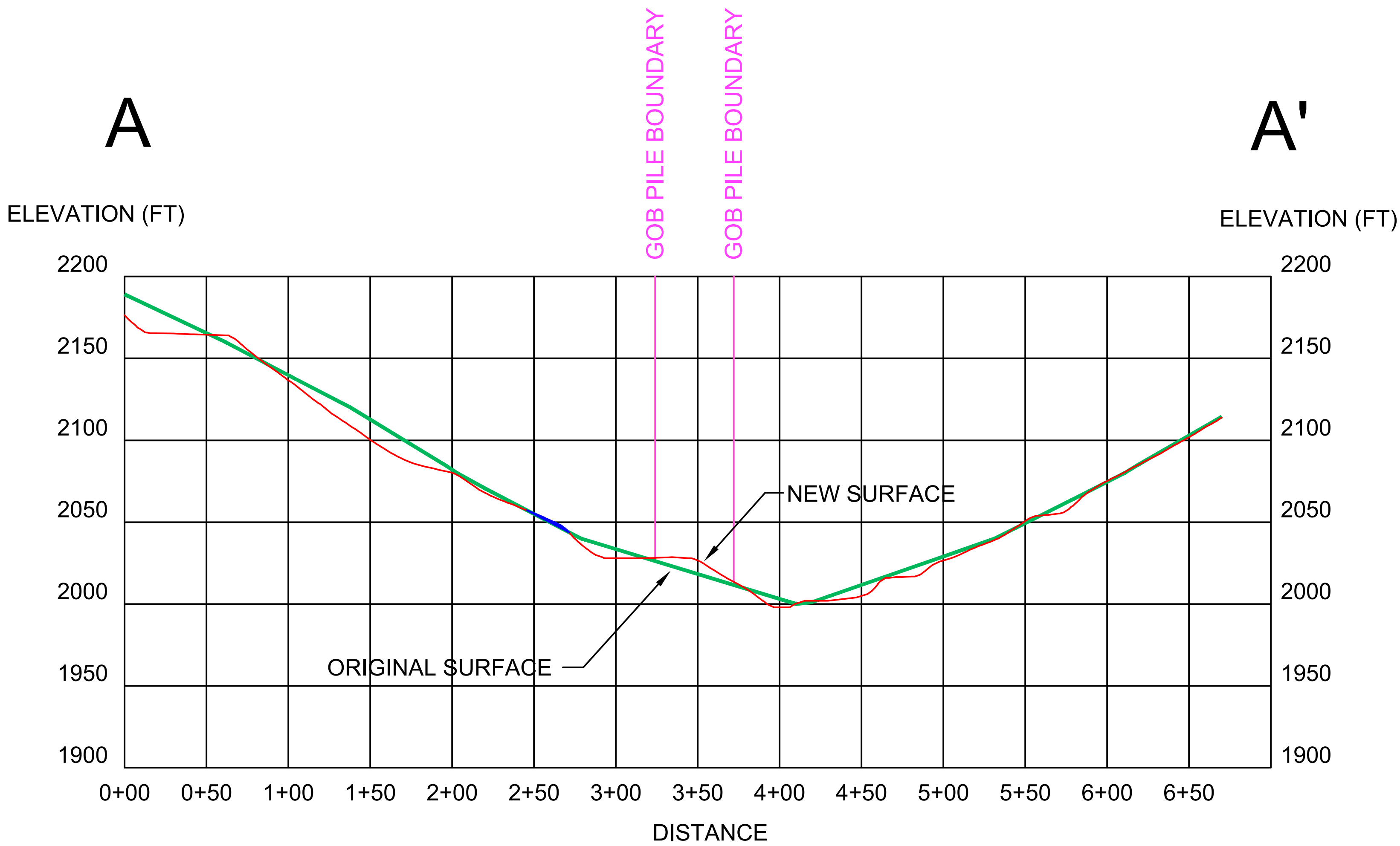
GOB PILE 76
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES	Drawn: SA Checked: SA Date: 9/2022 Scale: 1"=200' Project No.: VAEN100 File No. 77 79 CF.DWG	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 16A PLANVIEW GOB PILE 77



MARSHALL MILLER & ASSOCIATES	Drawn: SA Checked: SA Date: 9/2022 Scale: 1"=200' Project No.: VAEN100 File No. 77-79 CF.DWG	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 16B PLANVIEW GOB PILE 77



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	77-79 CF.DWG

Virginia Department Of Energy
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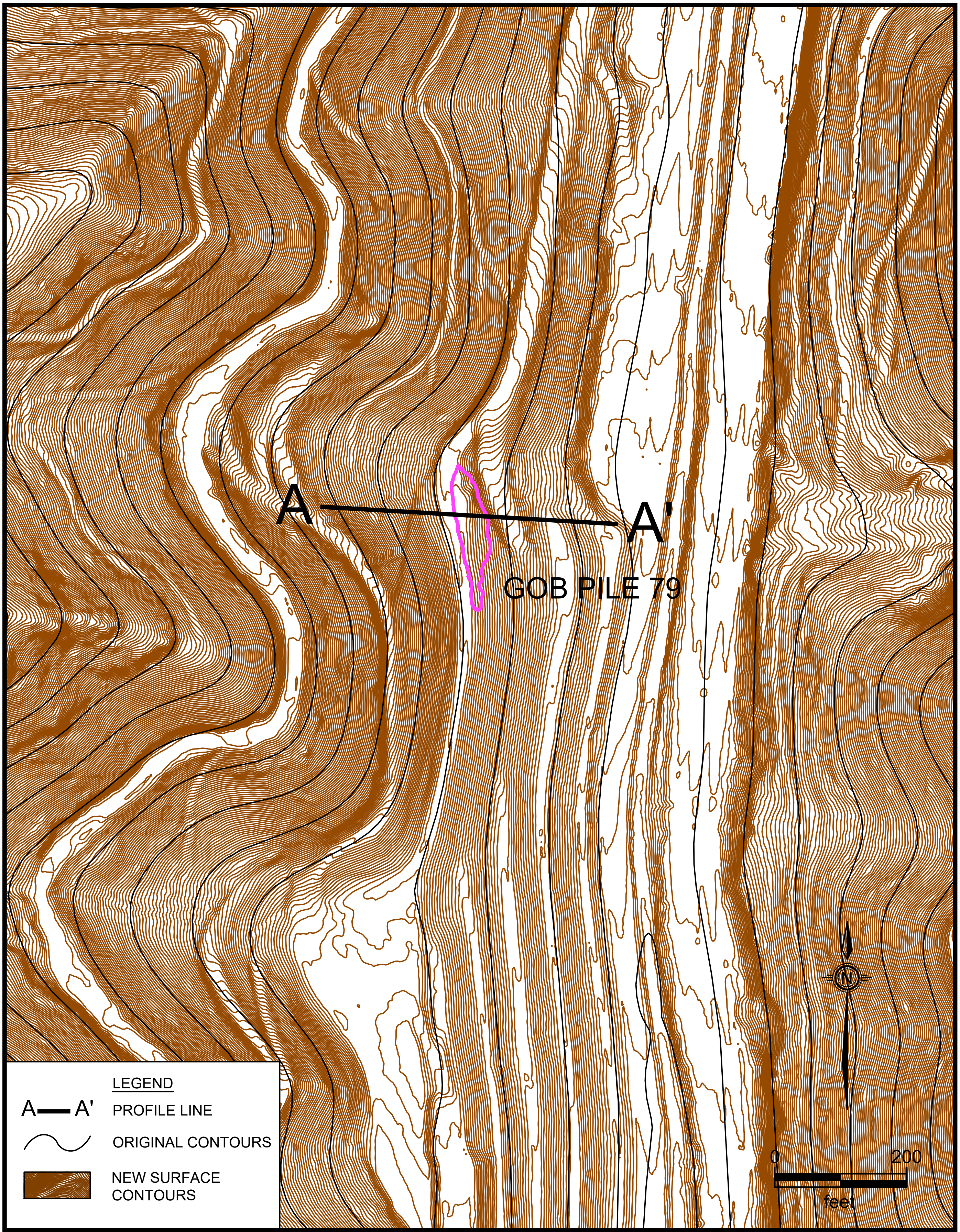
Big Stone Gap, Virginia

Exhibit 16C

GOB PILE 77
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	77 79 CF.DWG

Virginia Department Of Energy
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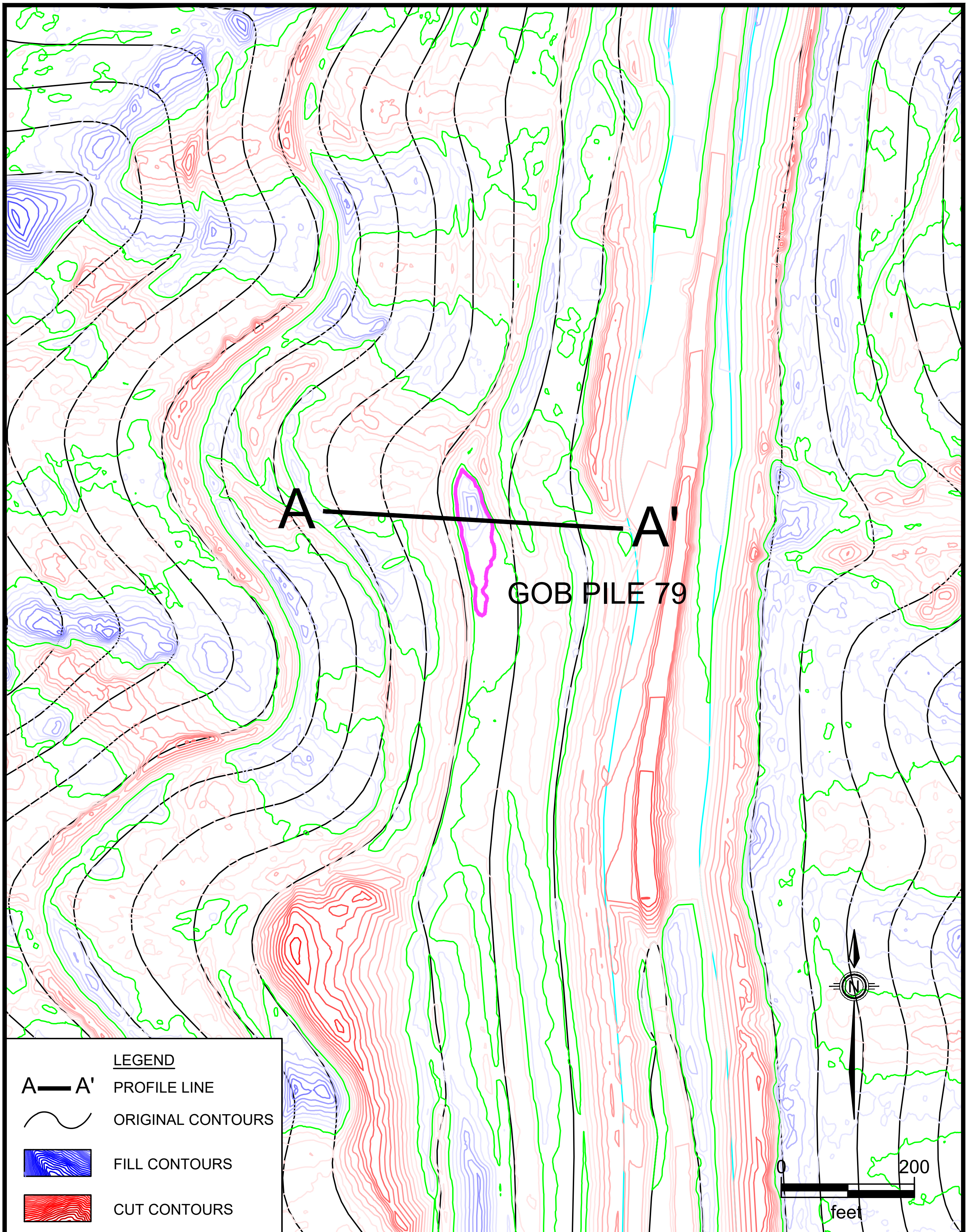
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 17A
PLANVIEW
GOB PILE 79



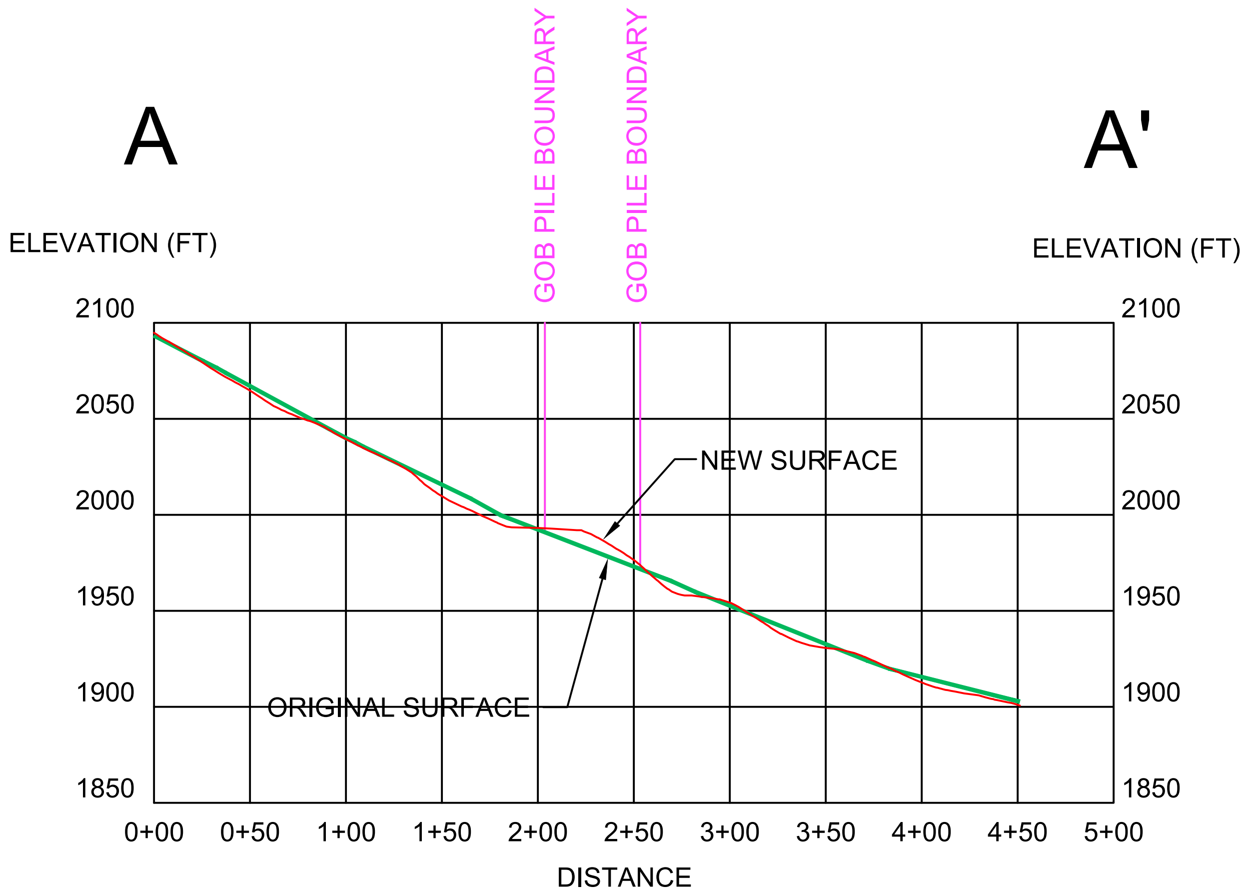
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	77-79 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 17B

PLANVIEW
GOB PILE 79



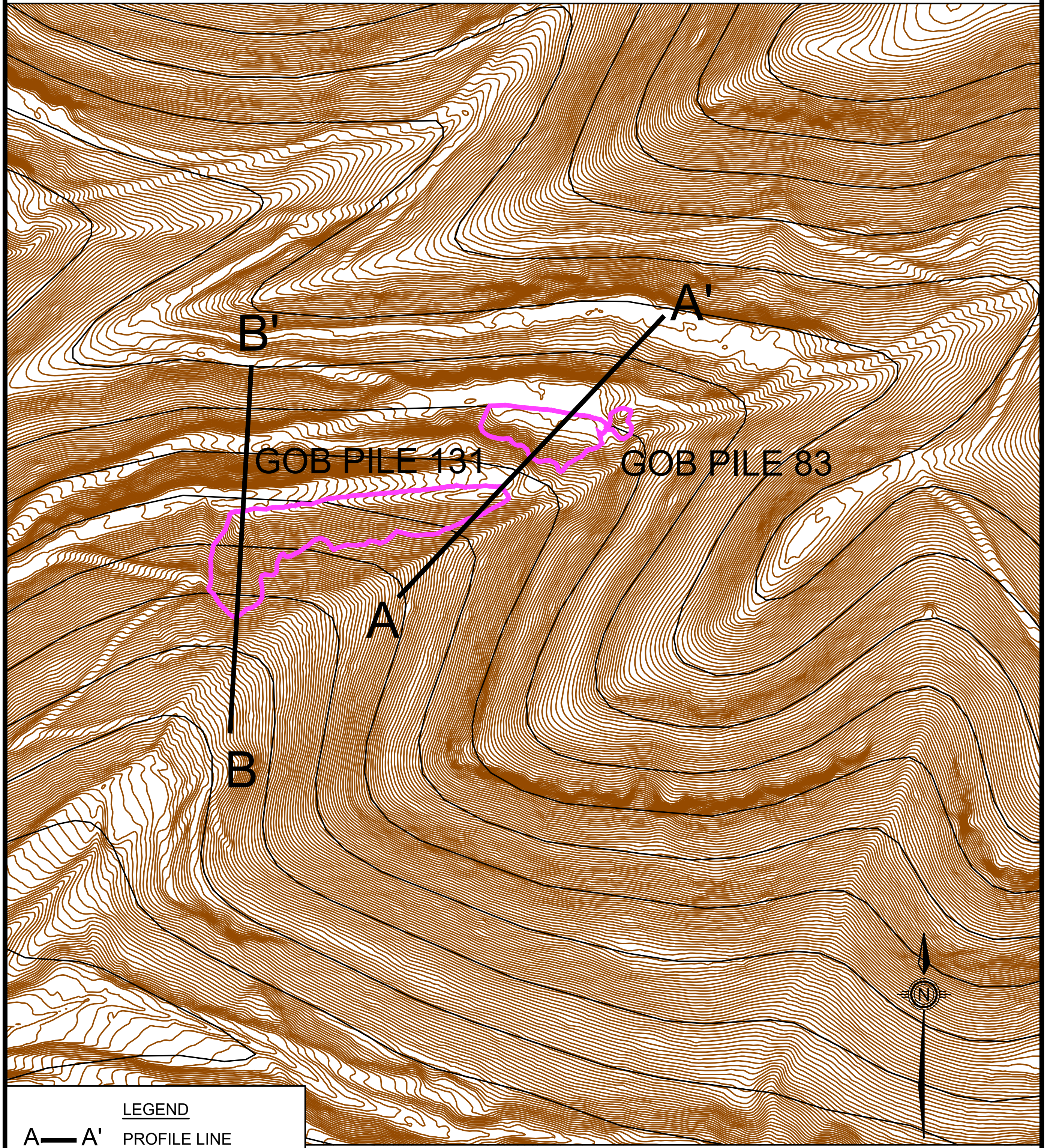
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	77-79 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 17C

GOB PILE 79
PROFILE A - A'



LEGEND

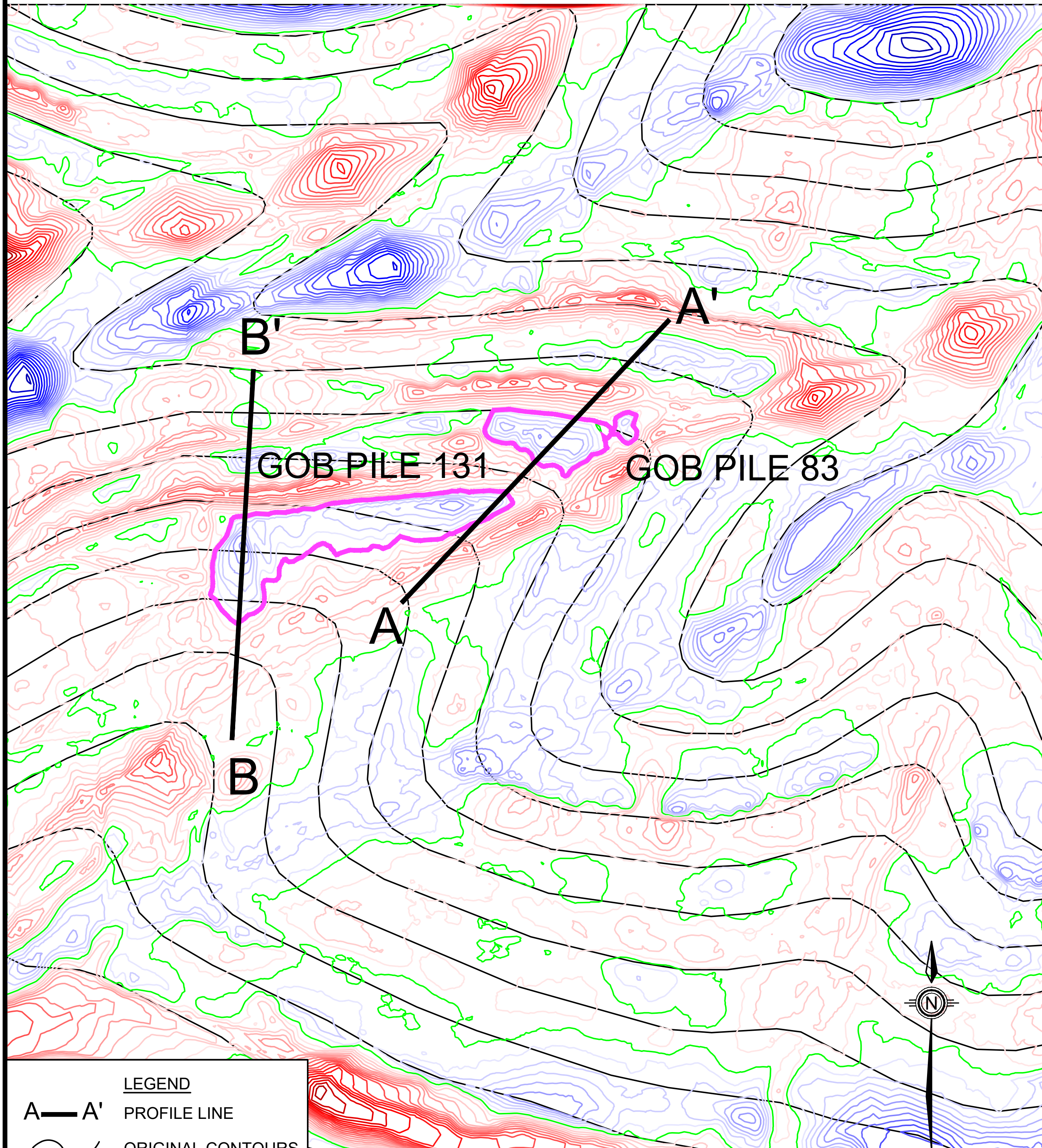
A—A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

0 200
feet

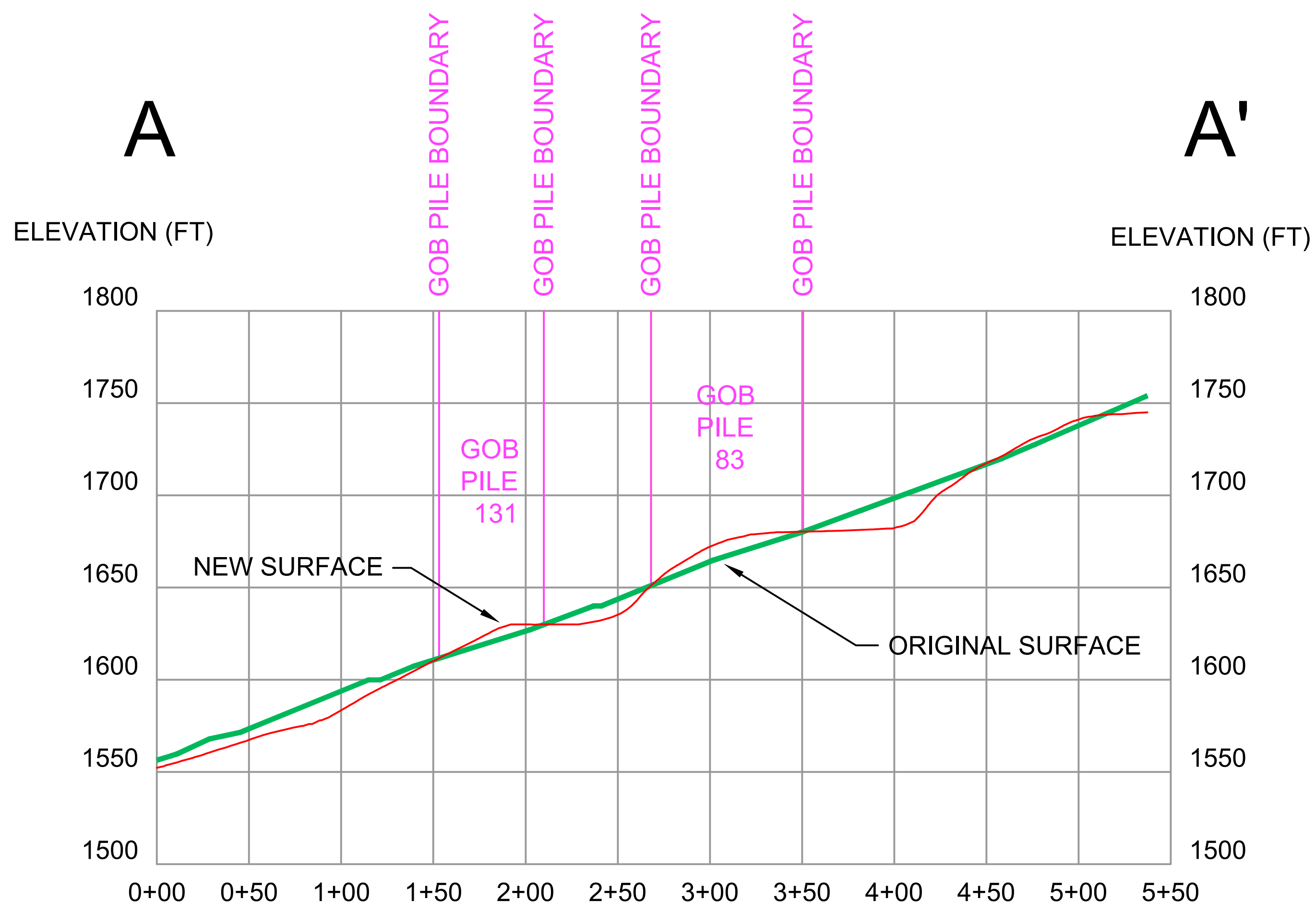
MARSHALL MILLER & ASSOCIATES	Drawn: SA	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 18A PLANVIEW GOB PILE 83 and 131
	Checked: SA		
	Date: 9/2022		
	Scale: 1"=200'		
	Project No.: VAEN100		
	File No. 83 131 CF.DWG		



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	83 131 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 18B
PLANVIEW
GOB PILE 83 and 131



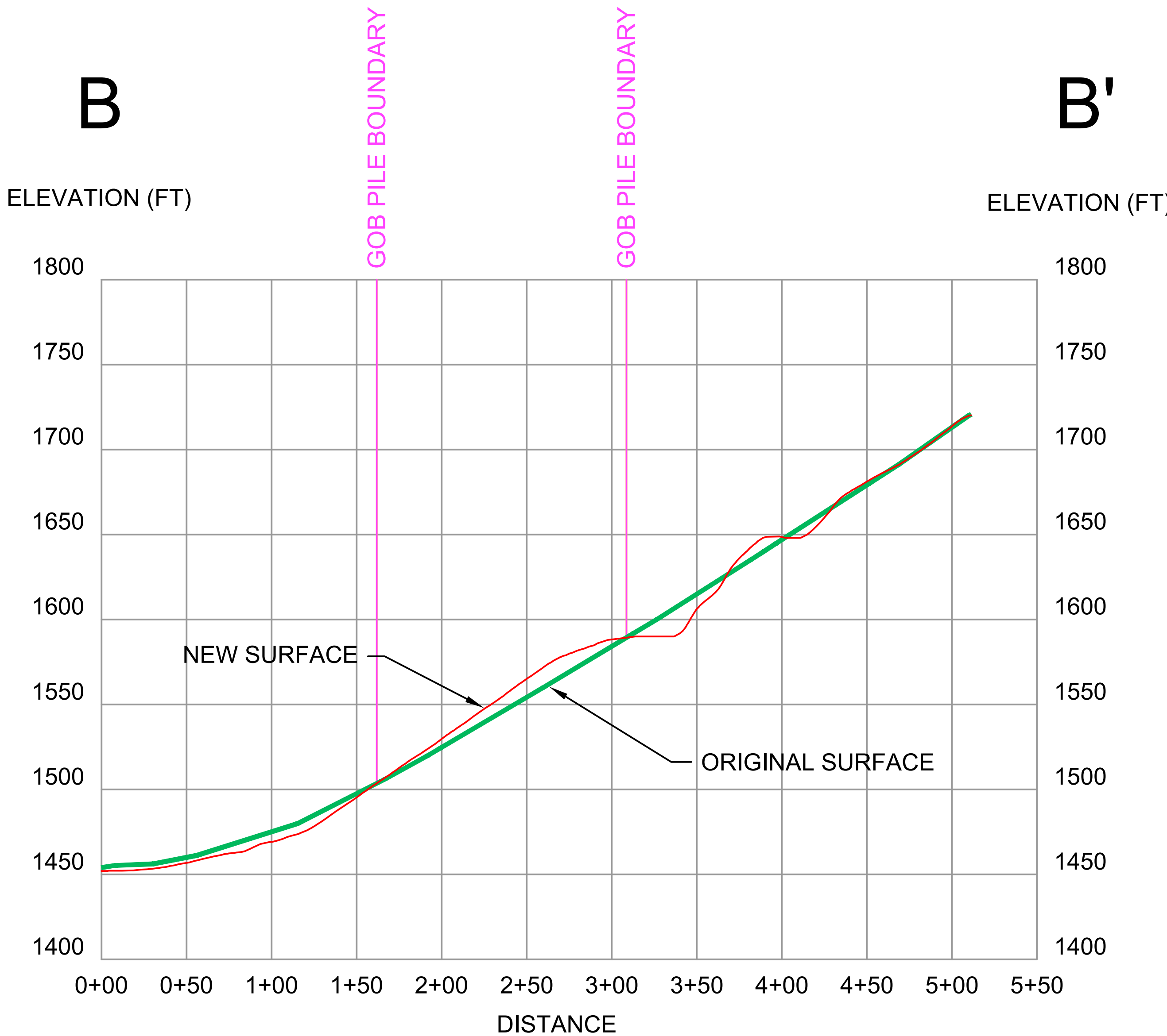
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	83 131 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 18C

GOB PILE 83
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES

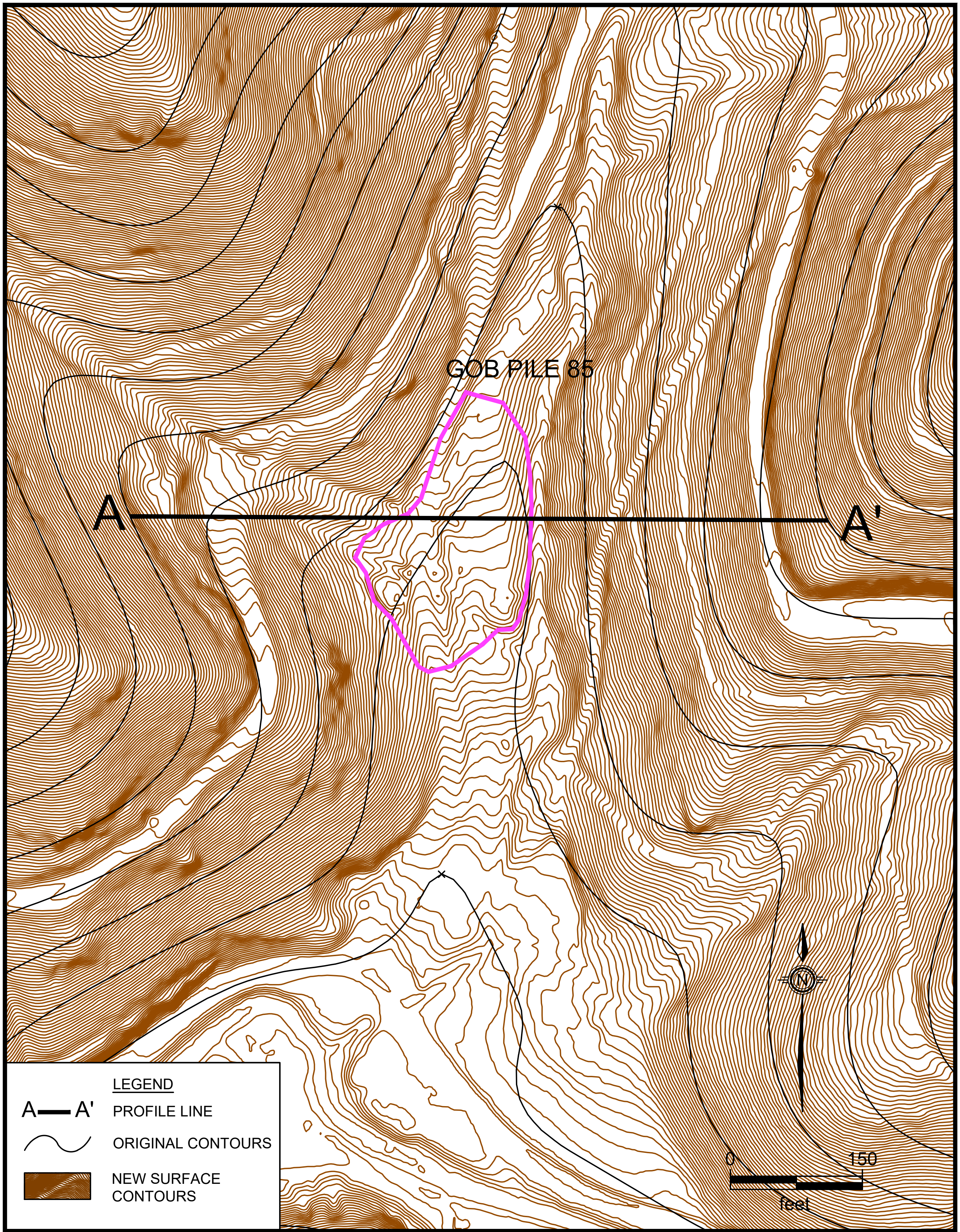
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	83 131 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 18D

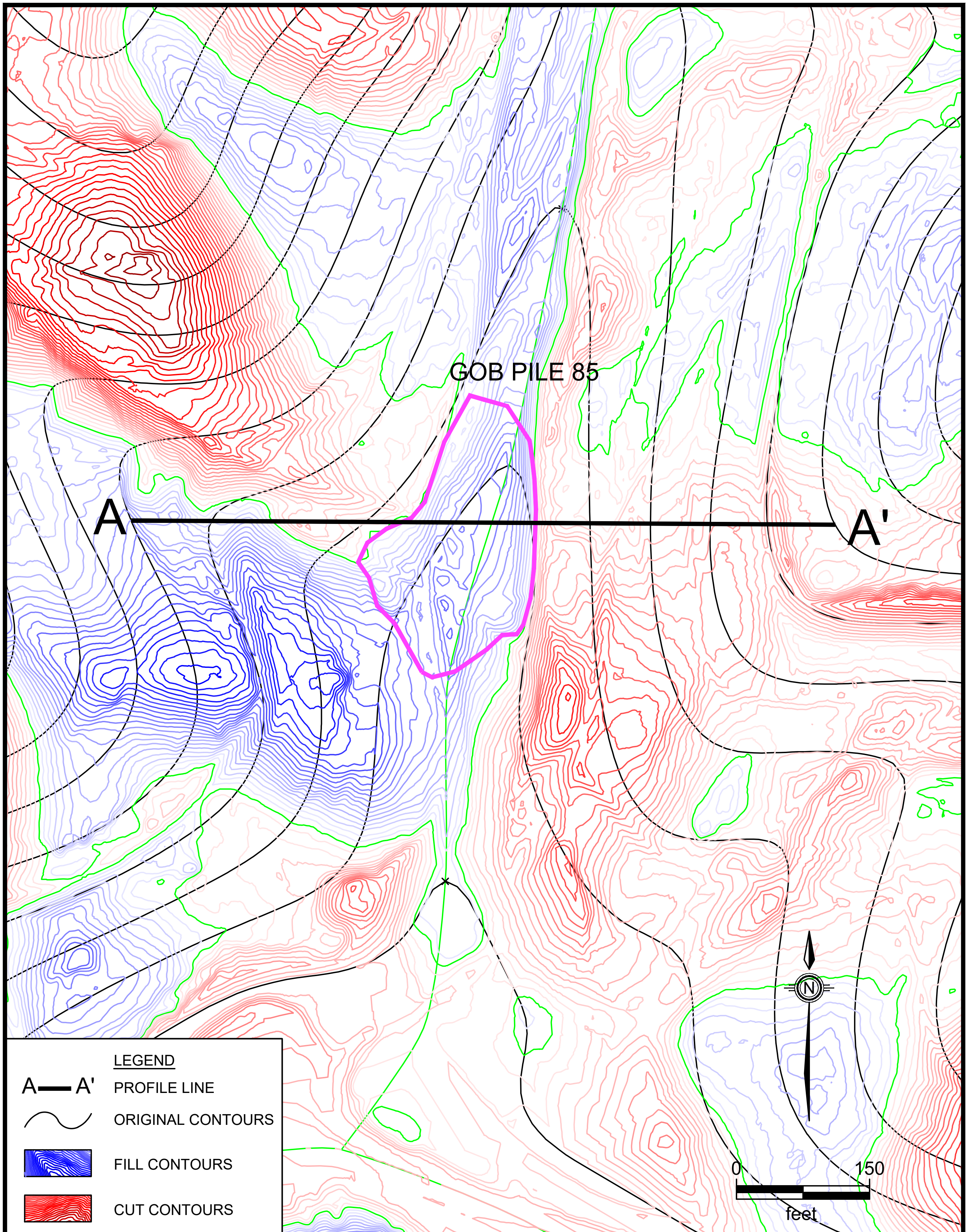
GOB PILE 131
PROFILE B - B'



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=150'
Project No.:	VAEN100
File No.	85 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 19A
PLANVIEW
GOB PILE 85



MARSHALL MILLER & ASSOCIATES

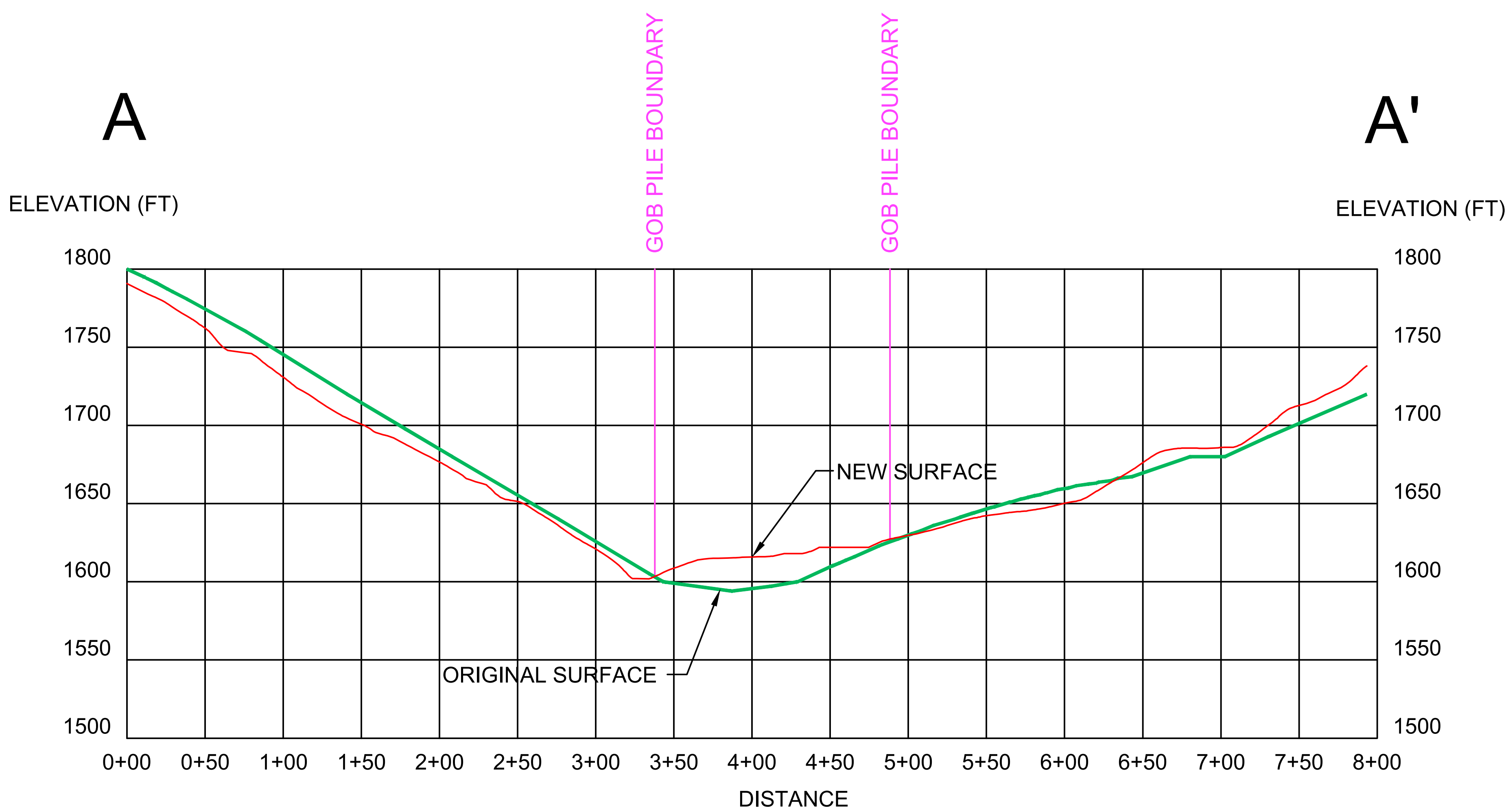
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=150'
Project No.:	VAEN100
File No.	85 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 19B

PLANVIEW
GOB PILE 85



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	85 CF.DWG

Virginia Department Of Energy
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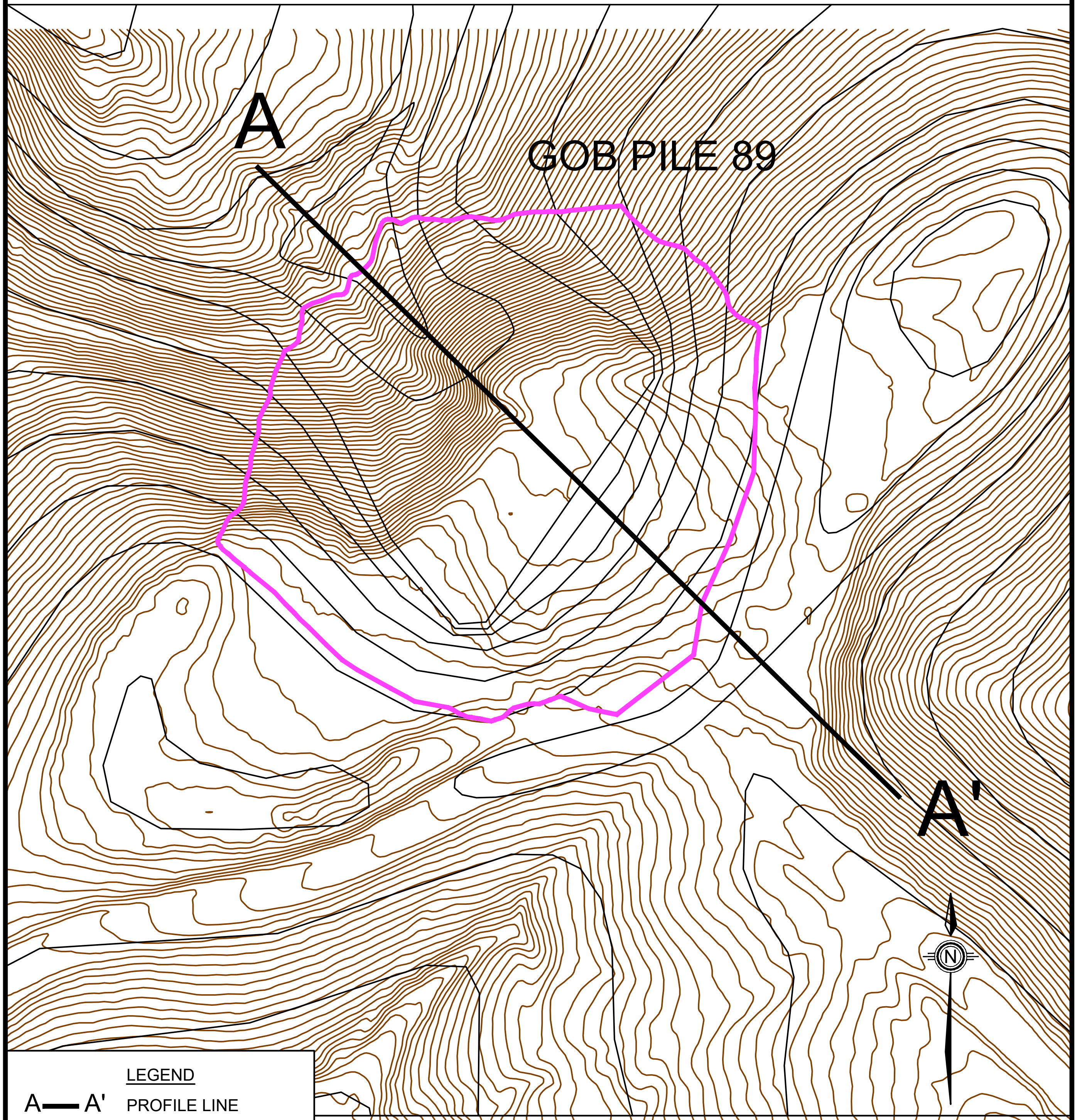
Big Stone Gap, Virginia

Exhibit 19C

GOB PILE 85
PROFILE A - A'



LEGEND

A —— A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

0 100
feet

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=100'
Project No.:	VAEN100
File No.	89 CF.DWG

Virginia Department Of Energy
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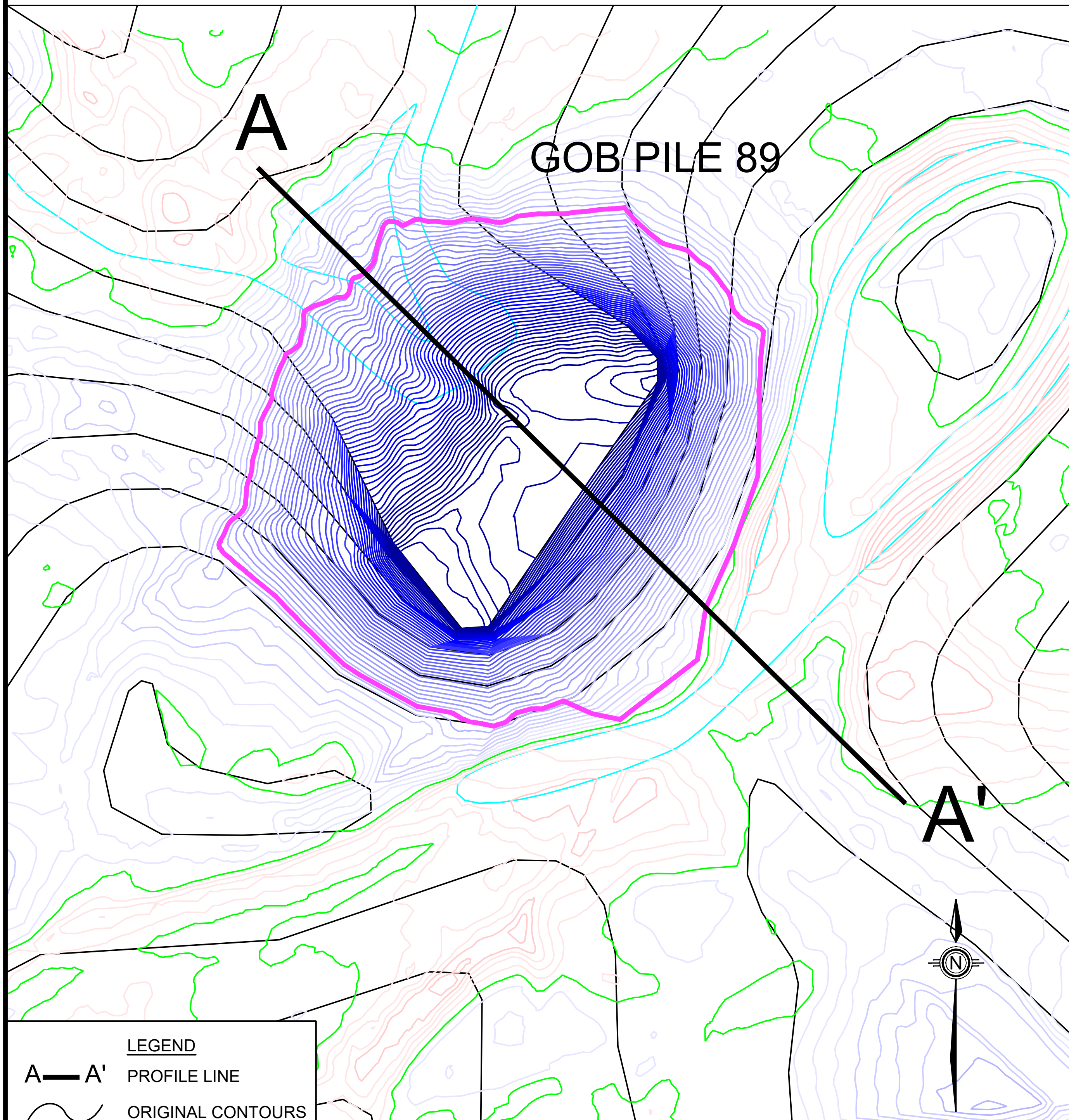
Big Stone Gap, Virginia

Exhibit 20A

PLANVIEW
GOB PILE 89



LEGEND

A — A' PROFILE LINE

ORIGINAL CONTOURS

FILL CONTOURS

CUT CONTOURS

MARSHALL MILLER & ASSOCIATES

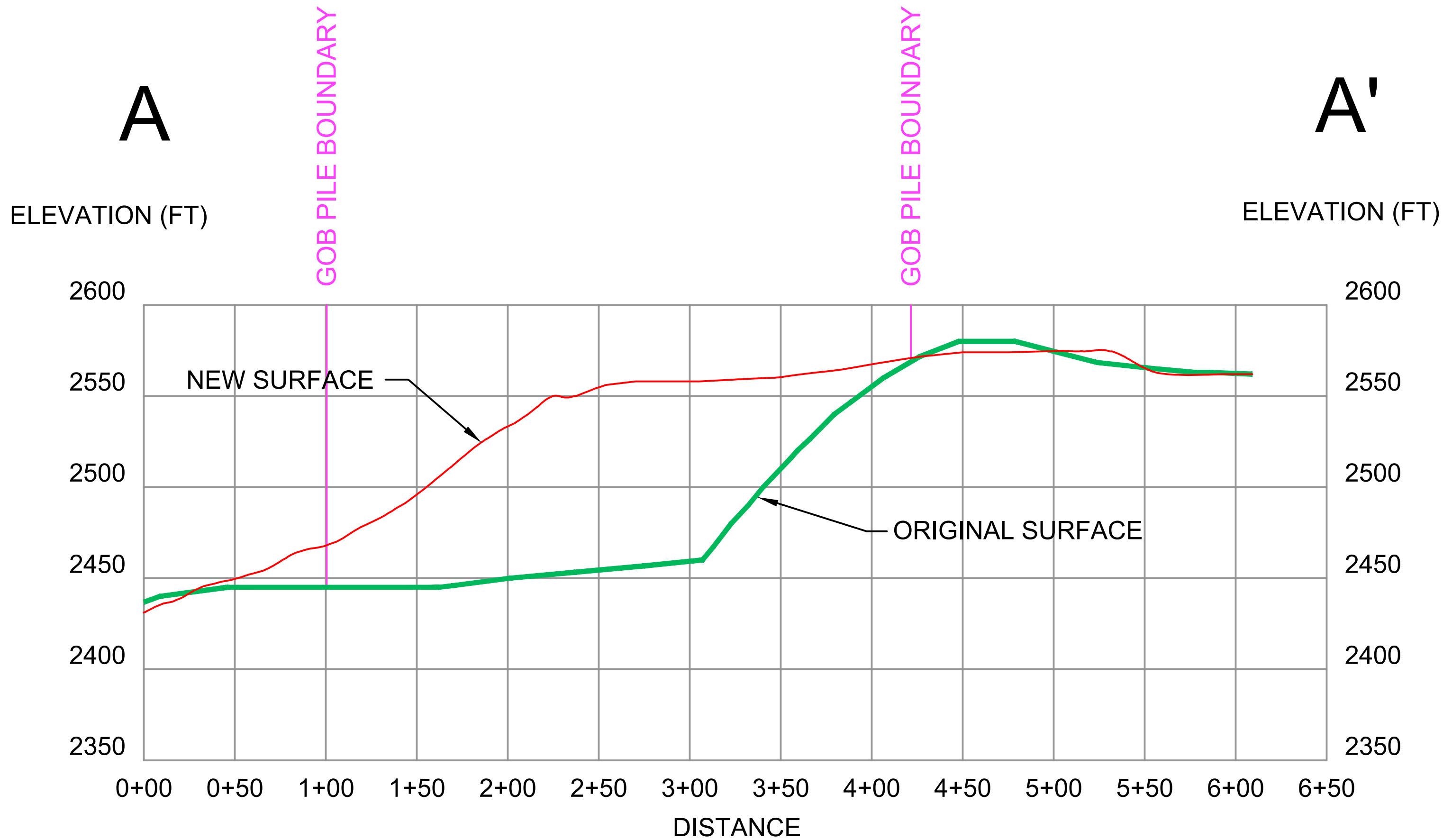
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=100'
Project No.:	VAEN100
File No.	89 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

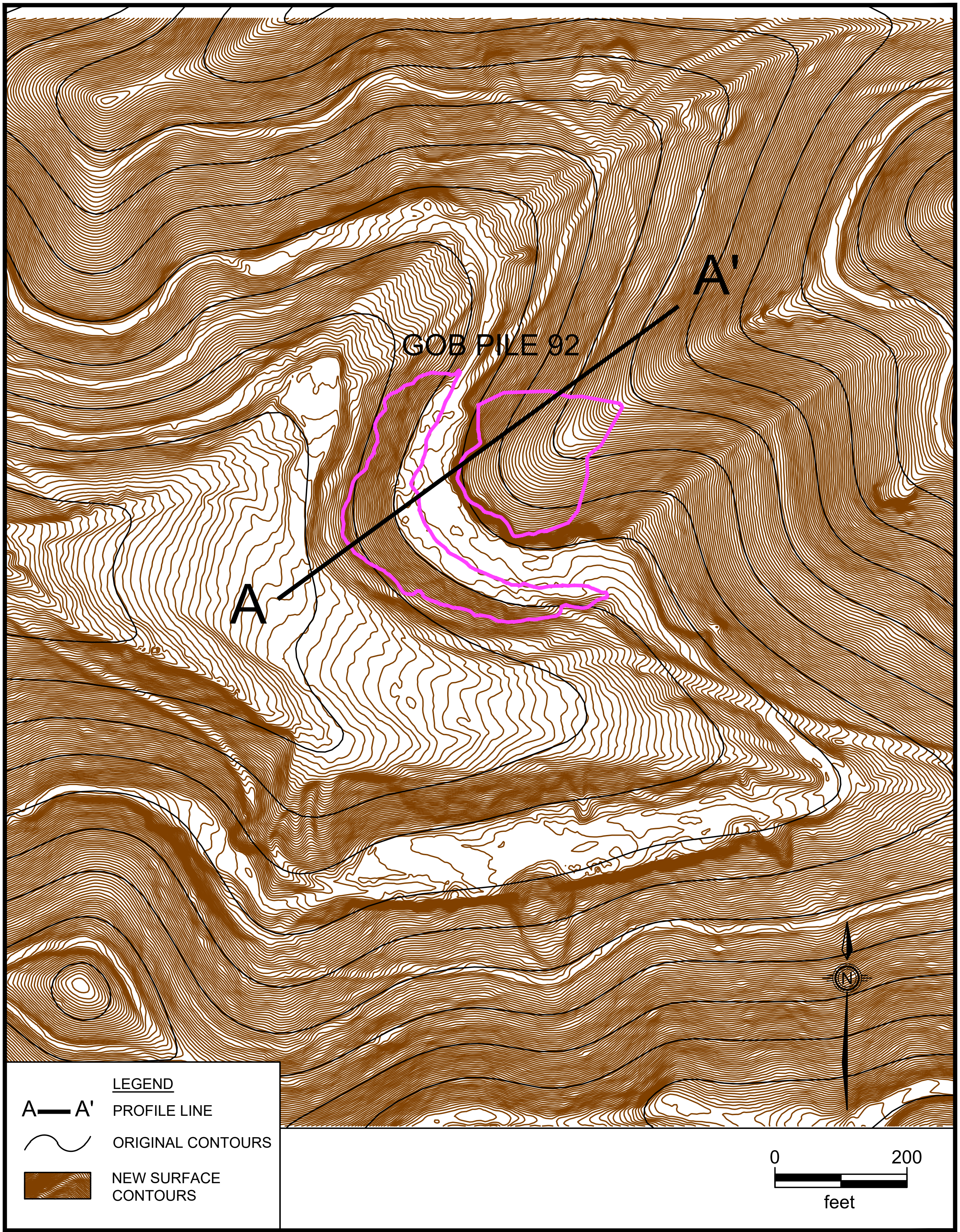
Big Stone Gap, Virginia

Exhibit 20B

PLANVIEW
GOB PILE 89



Drawn: SA		Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 20C GOB PILE 89 PROFILE A - A'
Checked: SA			
Date: 9/2022			
Scale: AS SHOWN			
Project No.: VAEN100			
File No. 89 CF.DWG			



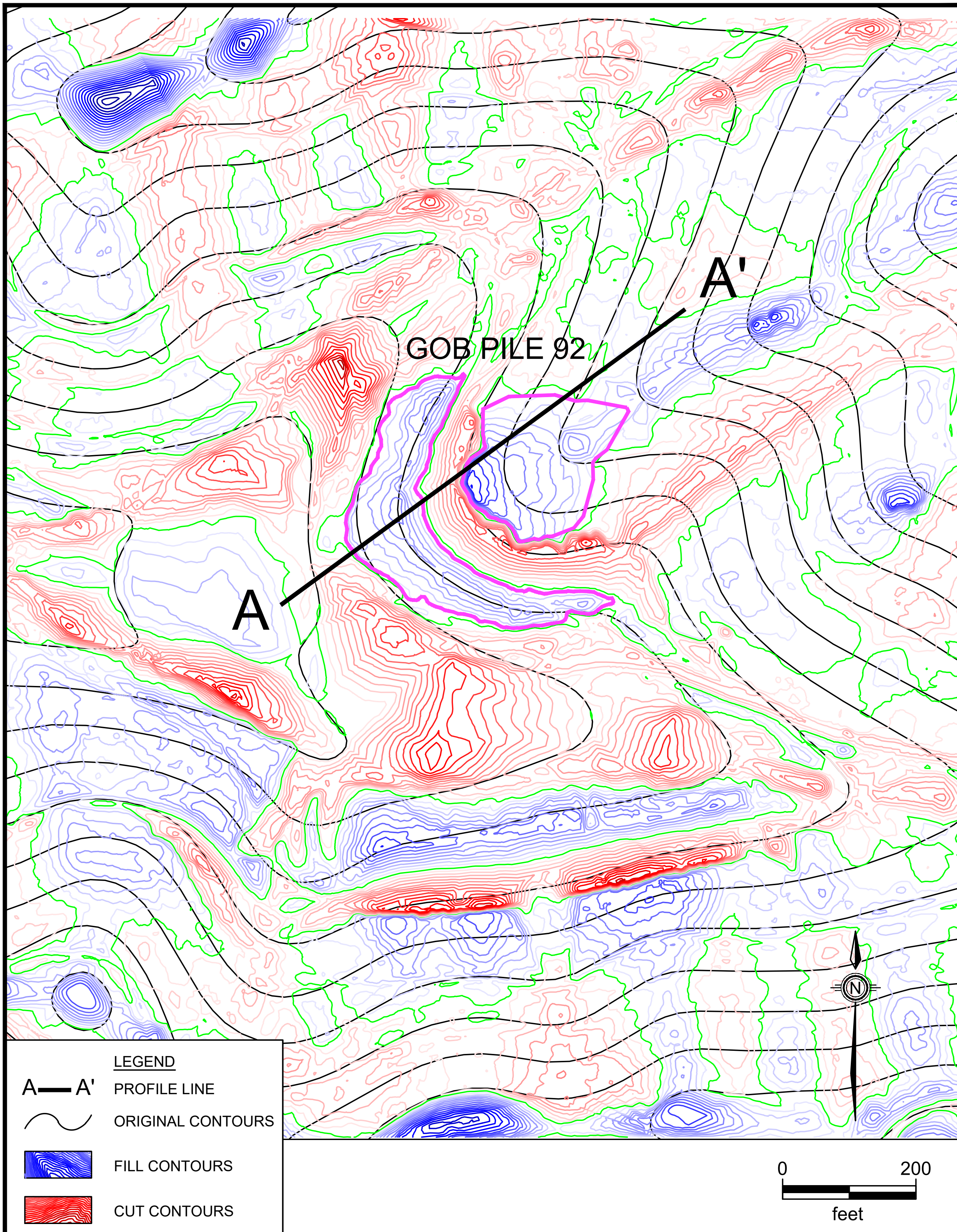
MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	92 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 21A
PLANVIEW
GOB PILE 92



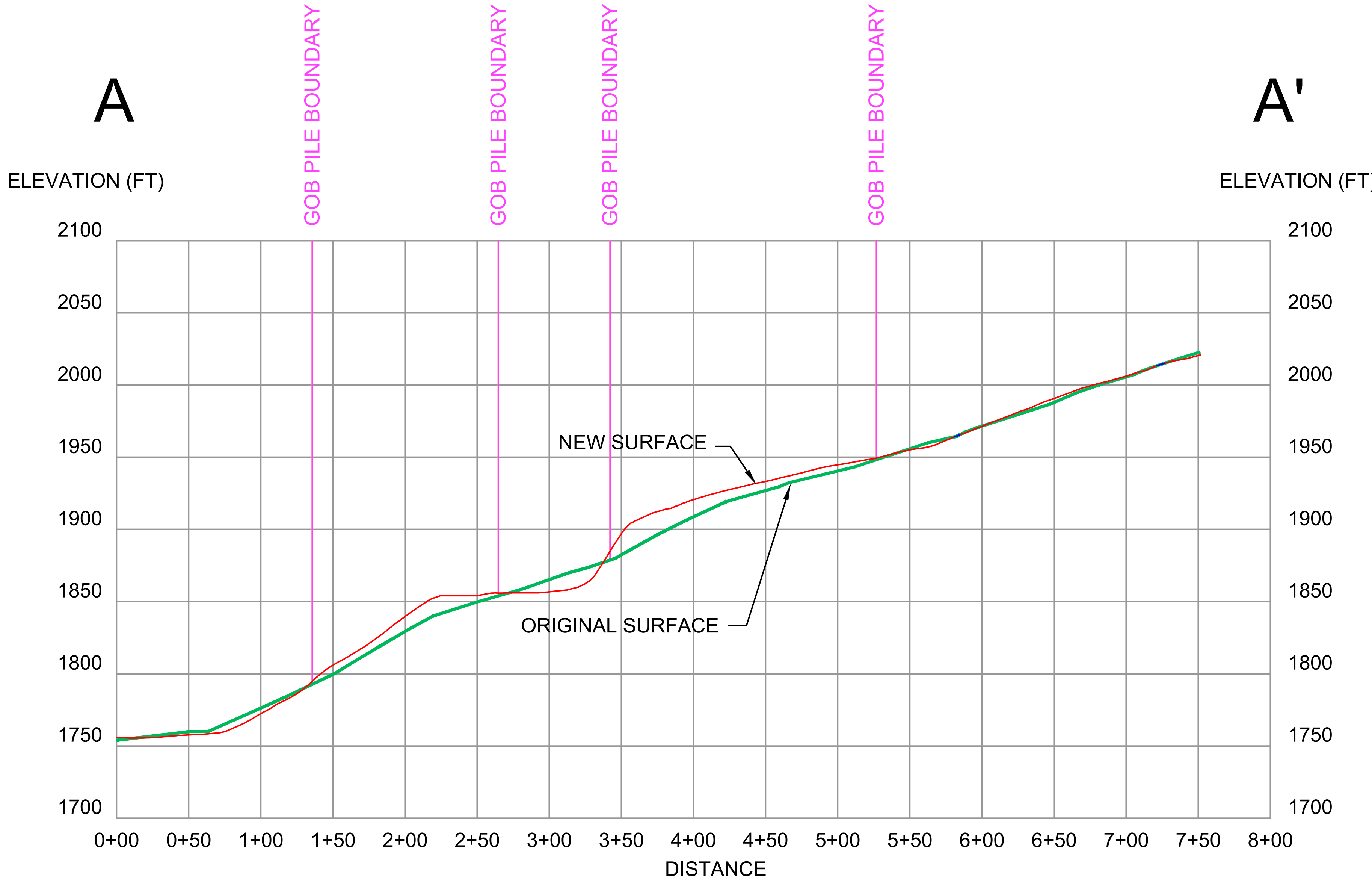
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	92 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 21B

PLANVIEW
GOB PILE 92



MARSHALL MILLER & ASSOCIATES

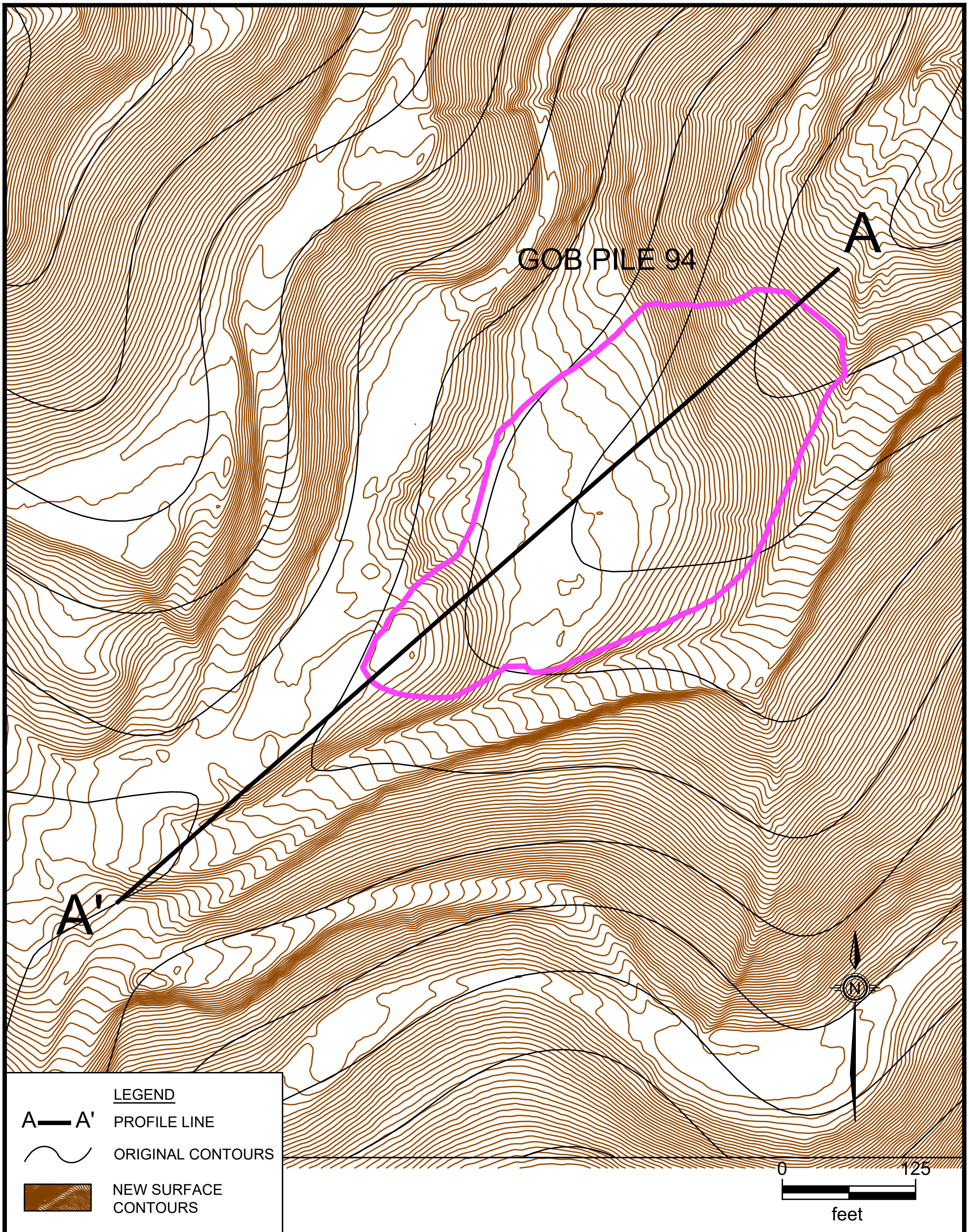
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	92 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

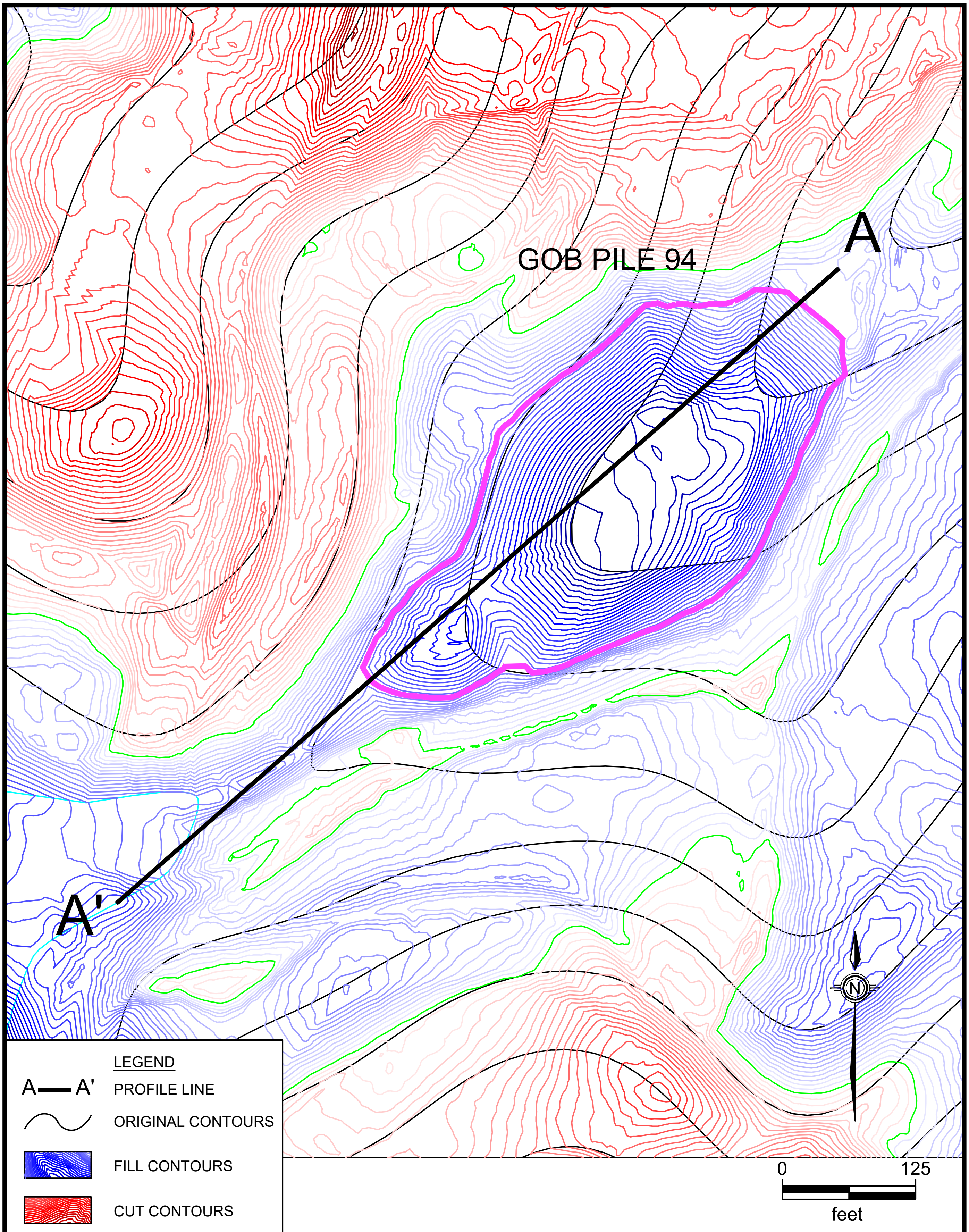
Big Stone Gap, Virginia

Exhibit 21C

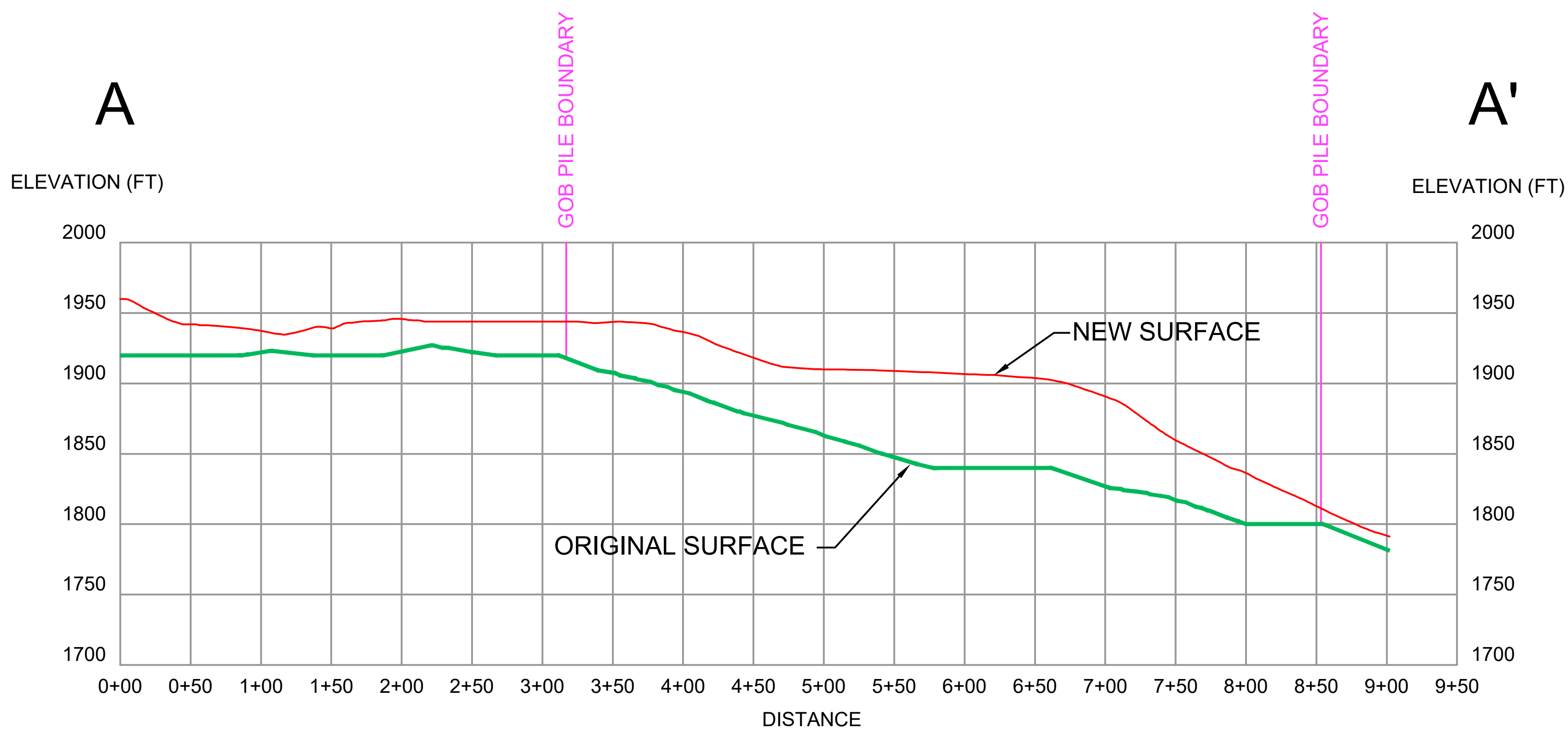
GOB PILE 92
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES	Drawn: SA	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 22A PLANVIEW GOB PILE 94
	Checked: SA		
	Date: 9/2022		
	Scale: 1"=125'		
	Project No.: VAEN100		
	File No. 94 CF.DWG		



MARSHALL MILLER & ASSOCIATES	Drawn: SA	Virginia Department Of Energy Waste Coal Piles Research Consulting Services Big Stone Gap, Virginia	Exhibit 22B PLANVIEW GOB PILE 94
	Checked: SA		
	Date: 9/2022		
	Scale: 1"=125'		
	Project No.: VAEN100		
	File No. 94 CF.DWG		



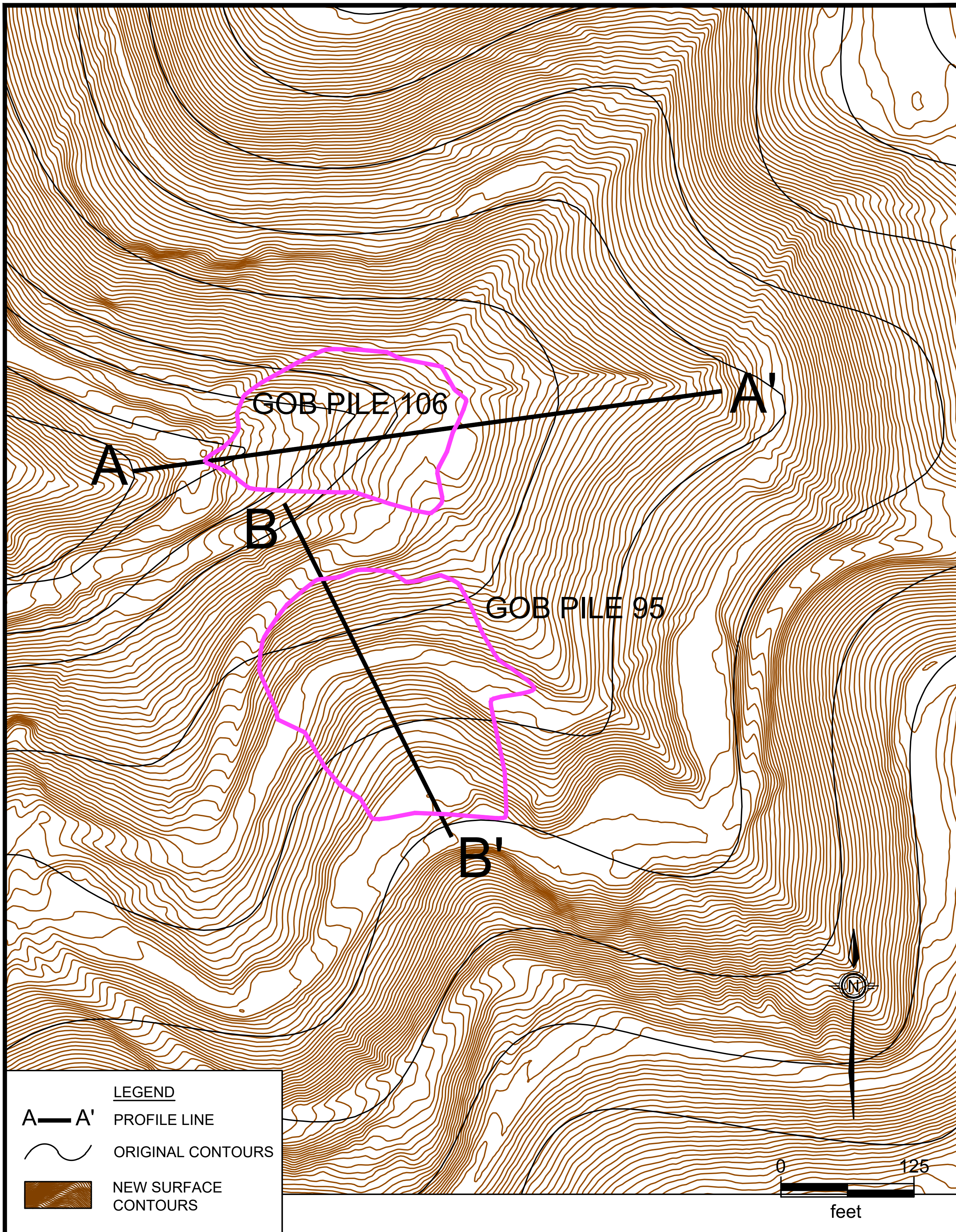
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	94 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 22C

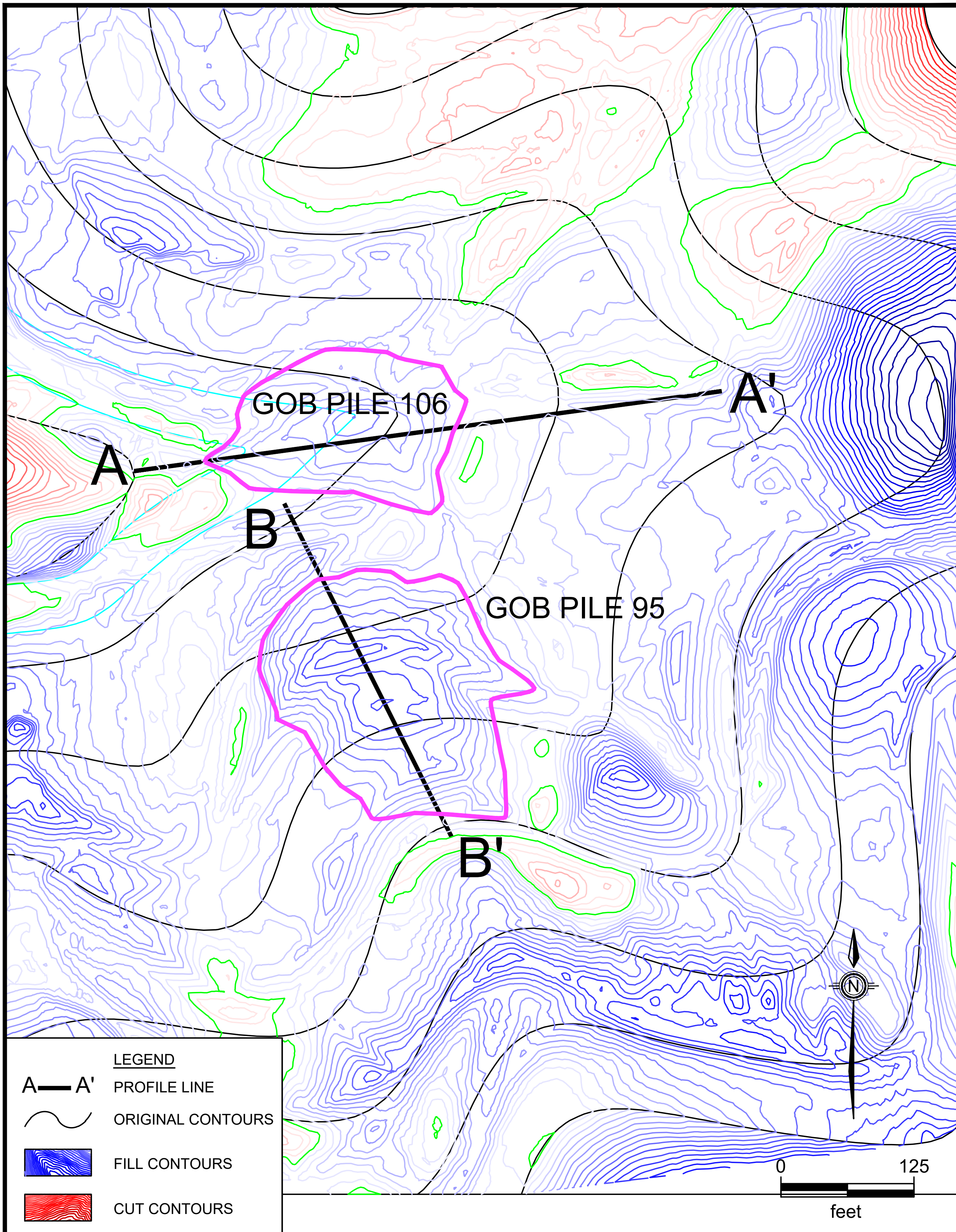
GOB PILE 94
PROFILE A - A'



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=125'
Project No.:	VAEN100
File No.	95 106 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 23A
PLANVIEW
GOB PILE 95 AND 106

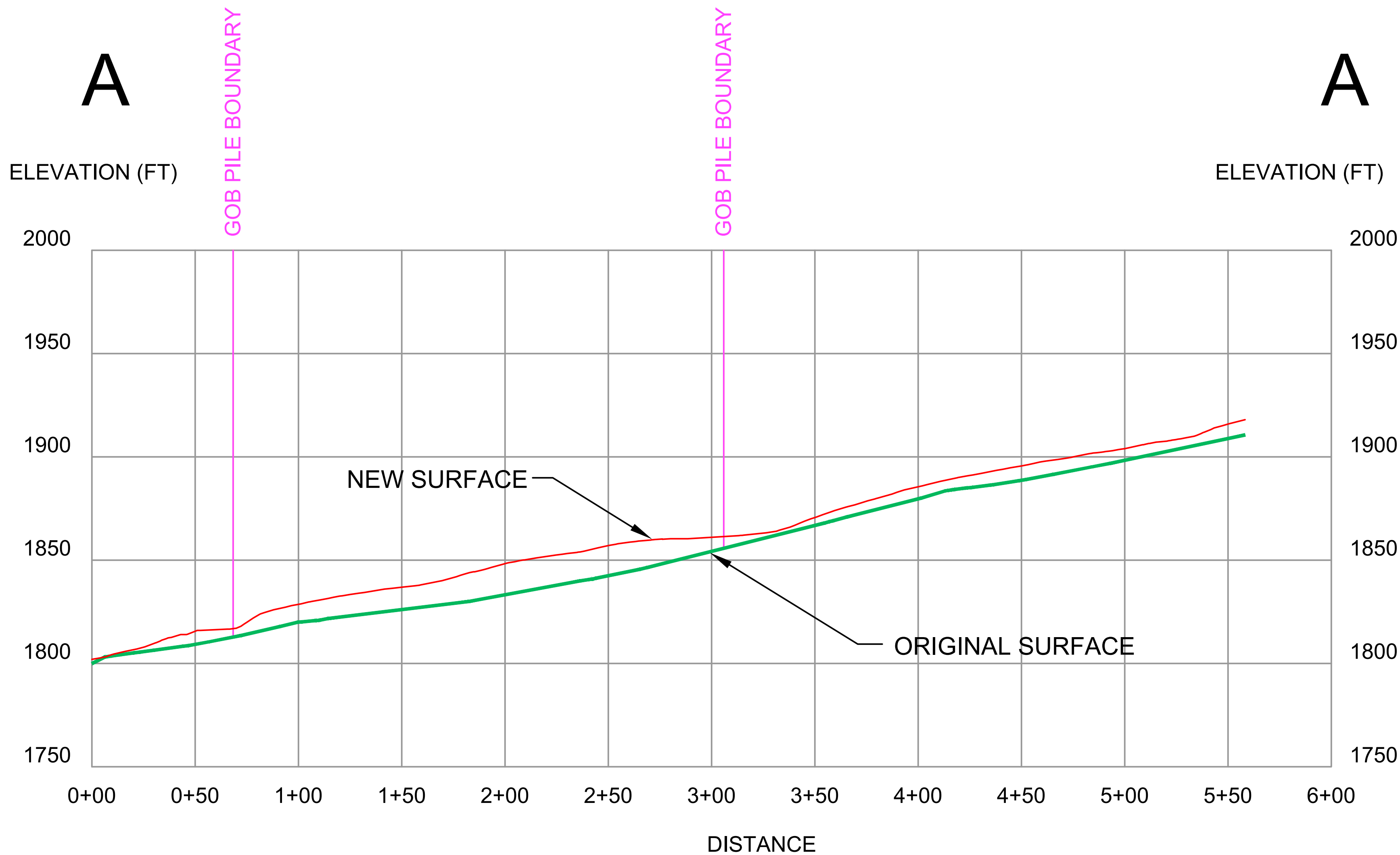


MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=125'
Project No.:	VAEN100
File No.	95-106 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 23B
PLANVIEW
GOB PILE 95 AND 106



MARSHALL MILLER & ASSOCIATES

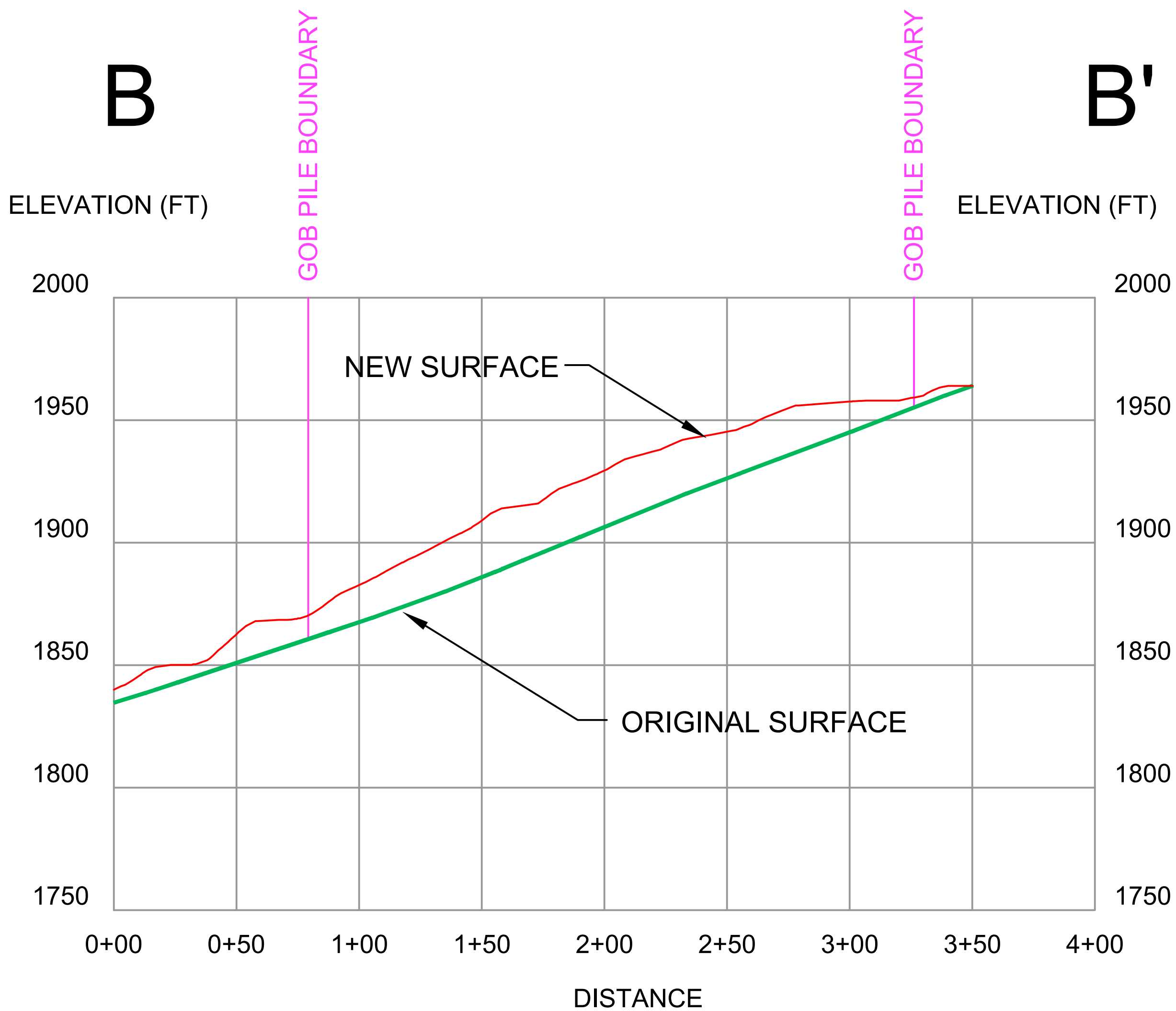
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	95-106 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 23C

GOB PILE 106
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES®

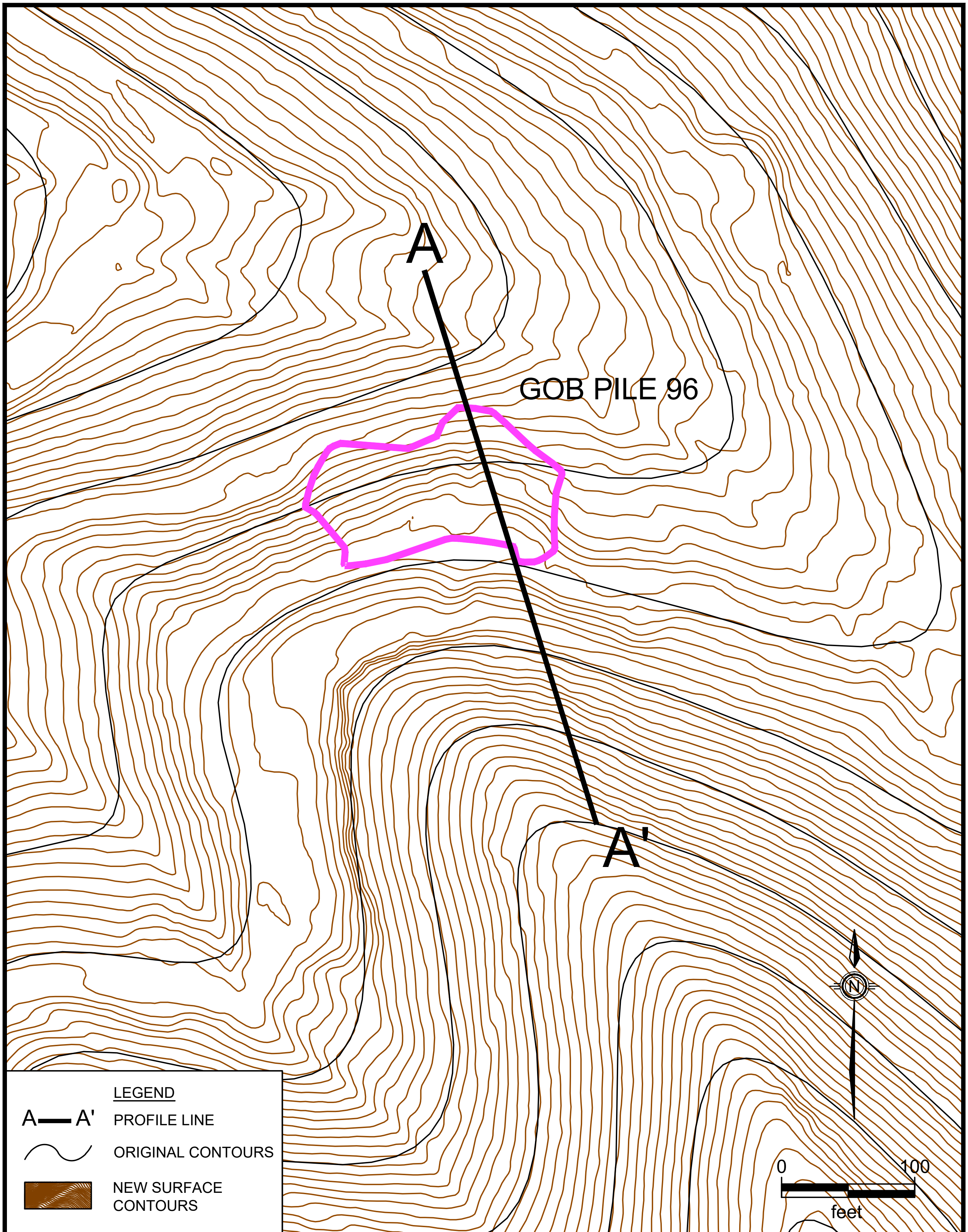
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	95-106 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 23D

GOB PILE 95
PROFILE B - B'



MARSHALL MILLER & ASSOCIATES

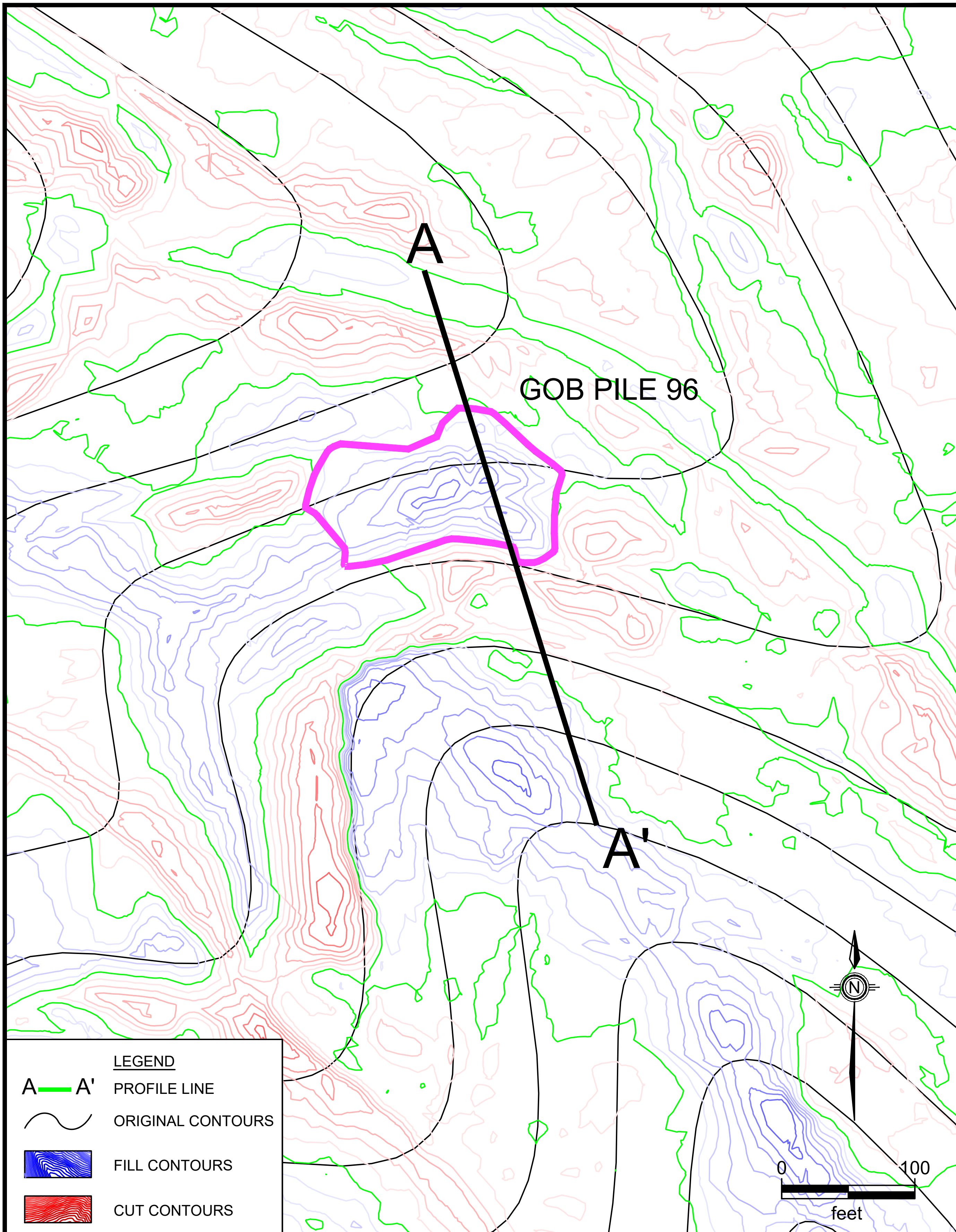
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=100'
Project No.:	VAEN100
File No.	96 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 24A

PLANVIEW
GOB PILE 96

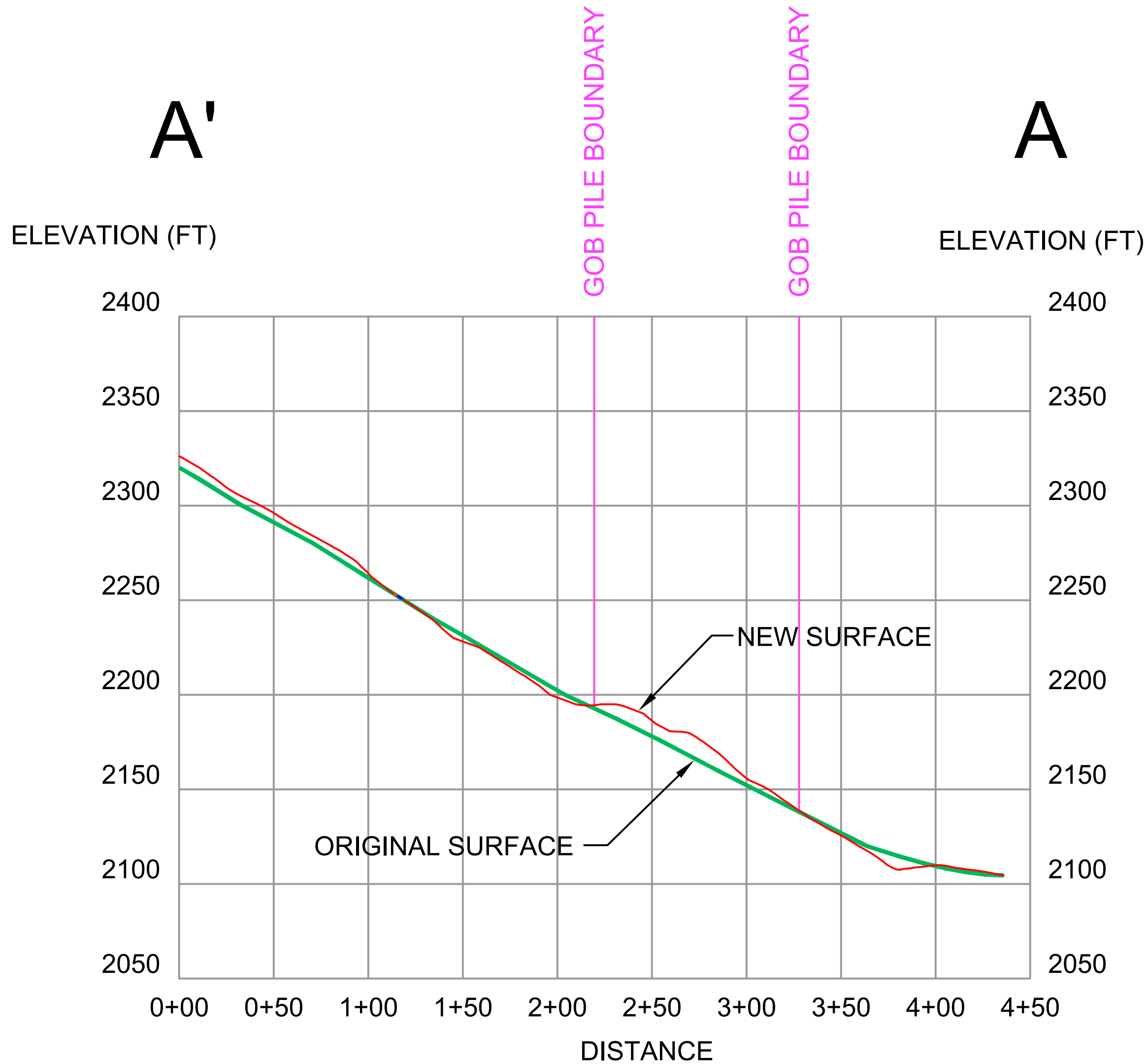


MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=100'
Project No.:	VAEN100
File No.	96 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 24B
PLANVIEW
GOB PILE 96



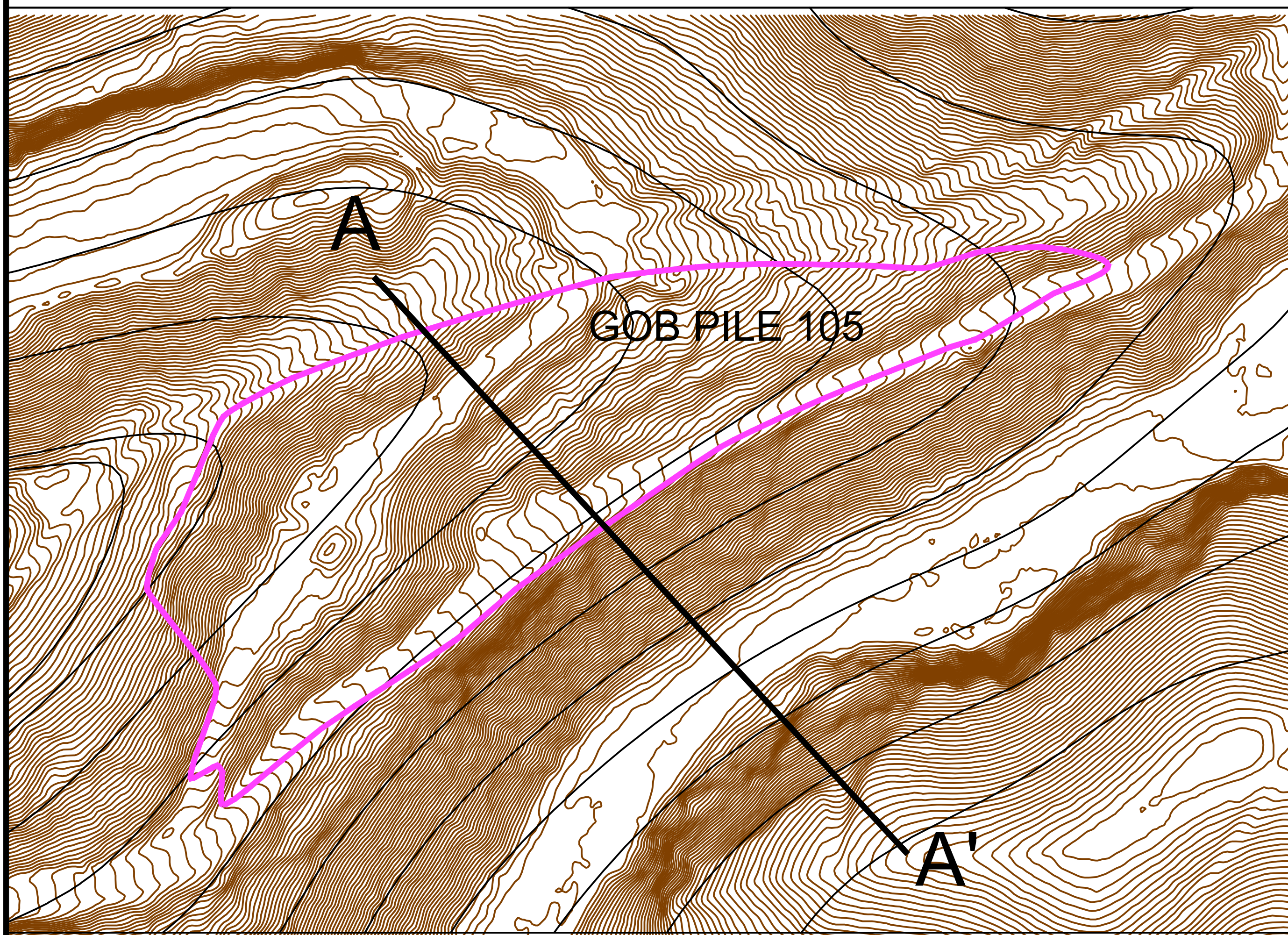
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	96 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 24C

GOB PILE 96
PROFILE A - A'



LEGEND

A—A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

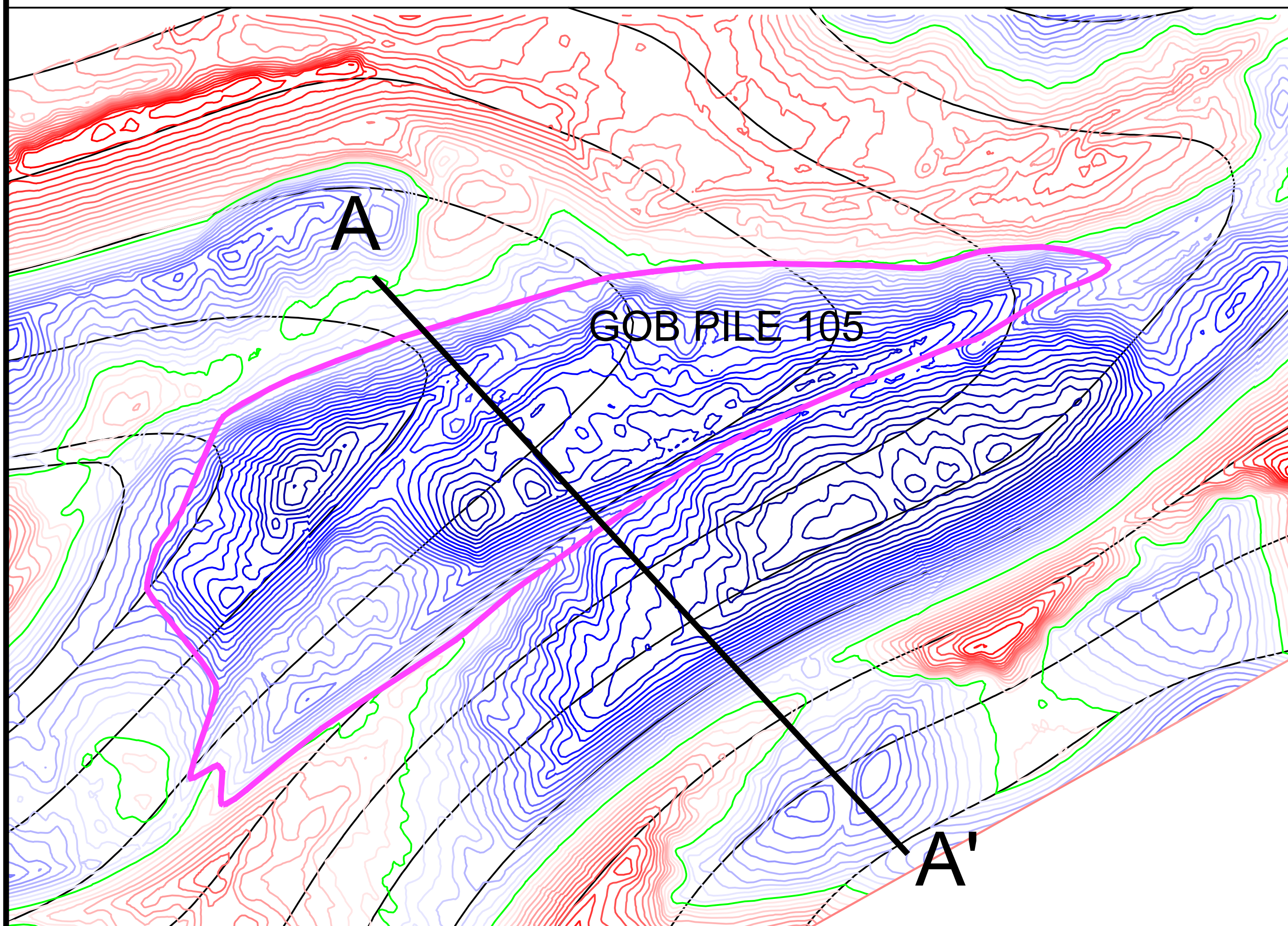
0 150
feet

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=150'
Project No.:	VAEN100
File No.	105 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 25A
PLANVIEW
GOB PILE 105



LEGEND

A — A' PROFILE LINE

ORIGINAL CONTOURS

FILL CONTOURS

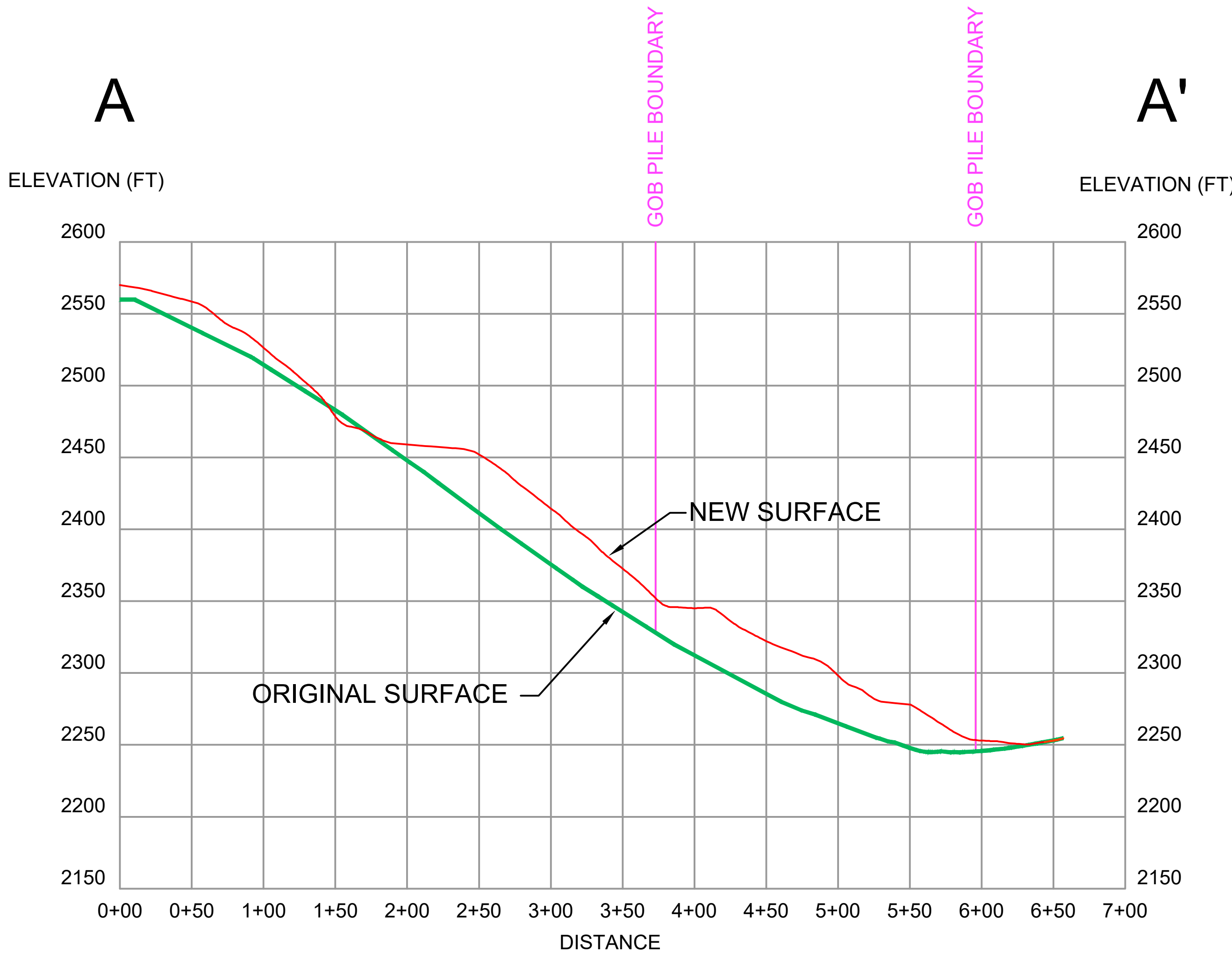
CUT CONTOURS

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=150'
Project No.:	VAEN100
File No.	105 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 25B
PLANVIEW
GOB PILE 105



MARSHALL MILLER & ASSOCIATES

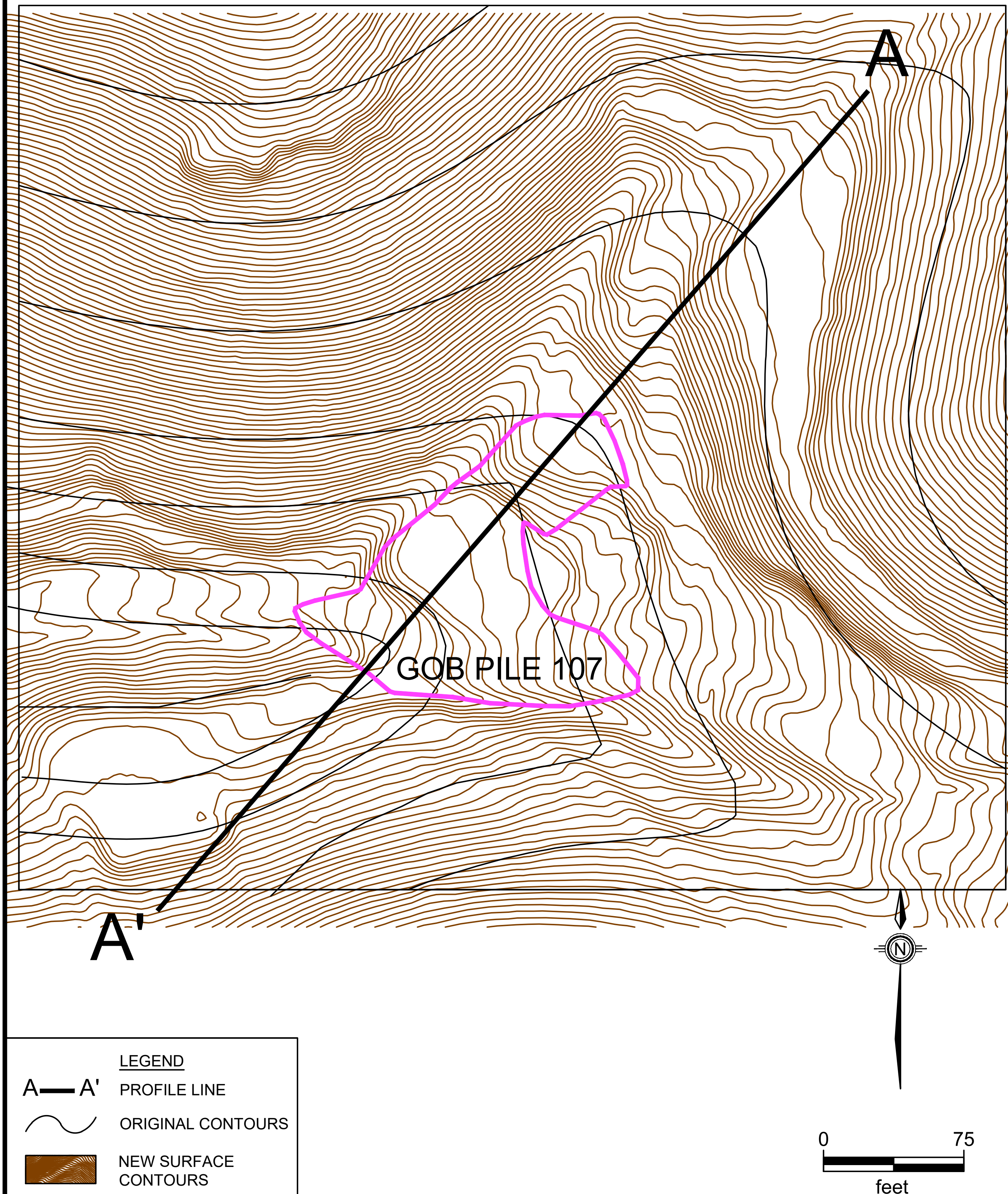
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	105 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 25C

GOB PILE 105
PROFILE A - A'



LEGEND

A — A' PROFILE LINE

ORIGINAL CONTOURS

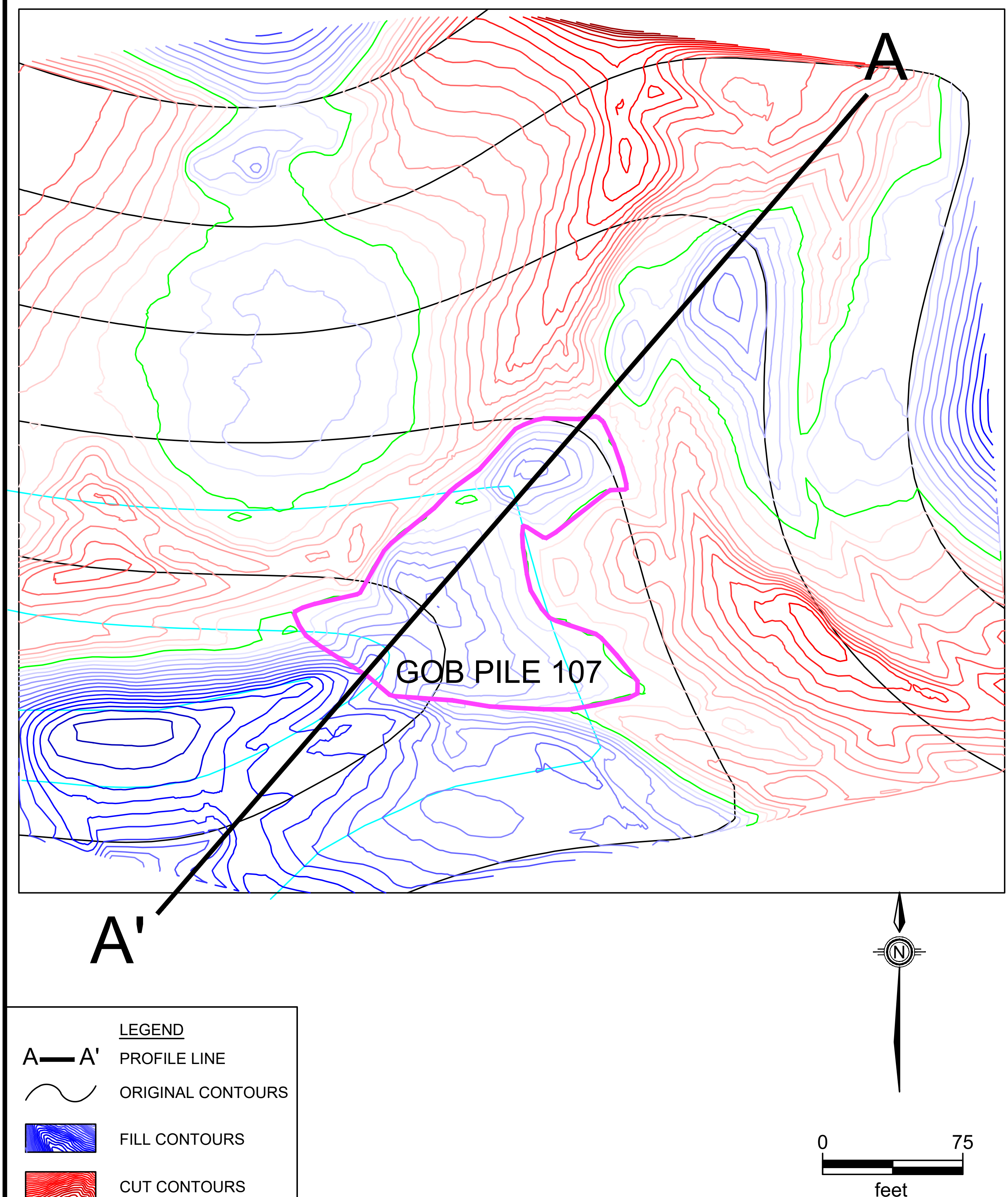
NEW SURFACE CONTOURS

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=75
Project No.:	VAEN100
File No.	107 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 26A
PLANVIEW
GOB PILE 107



LEGEND

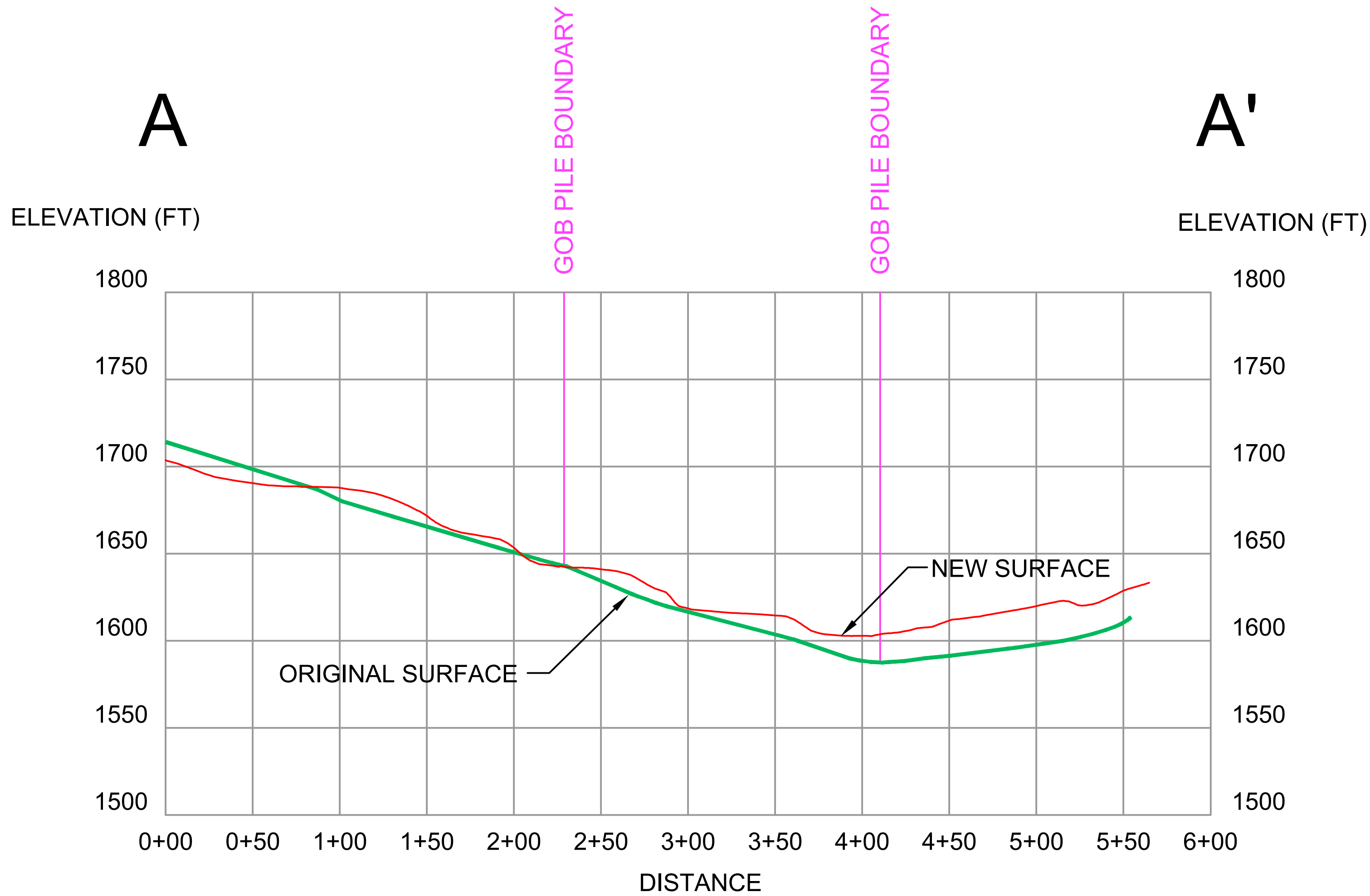
- A — A' PROFILE LINE
- ORIGINAL CONTOURS
- FILL CONTOURS
- CUT CONTOURS

MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=75
Project No.:	VAEN100
File No.	107 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 26B
PLANVIEW
GOB PILE 107



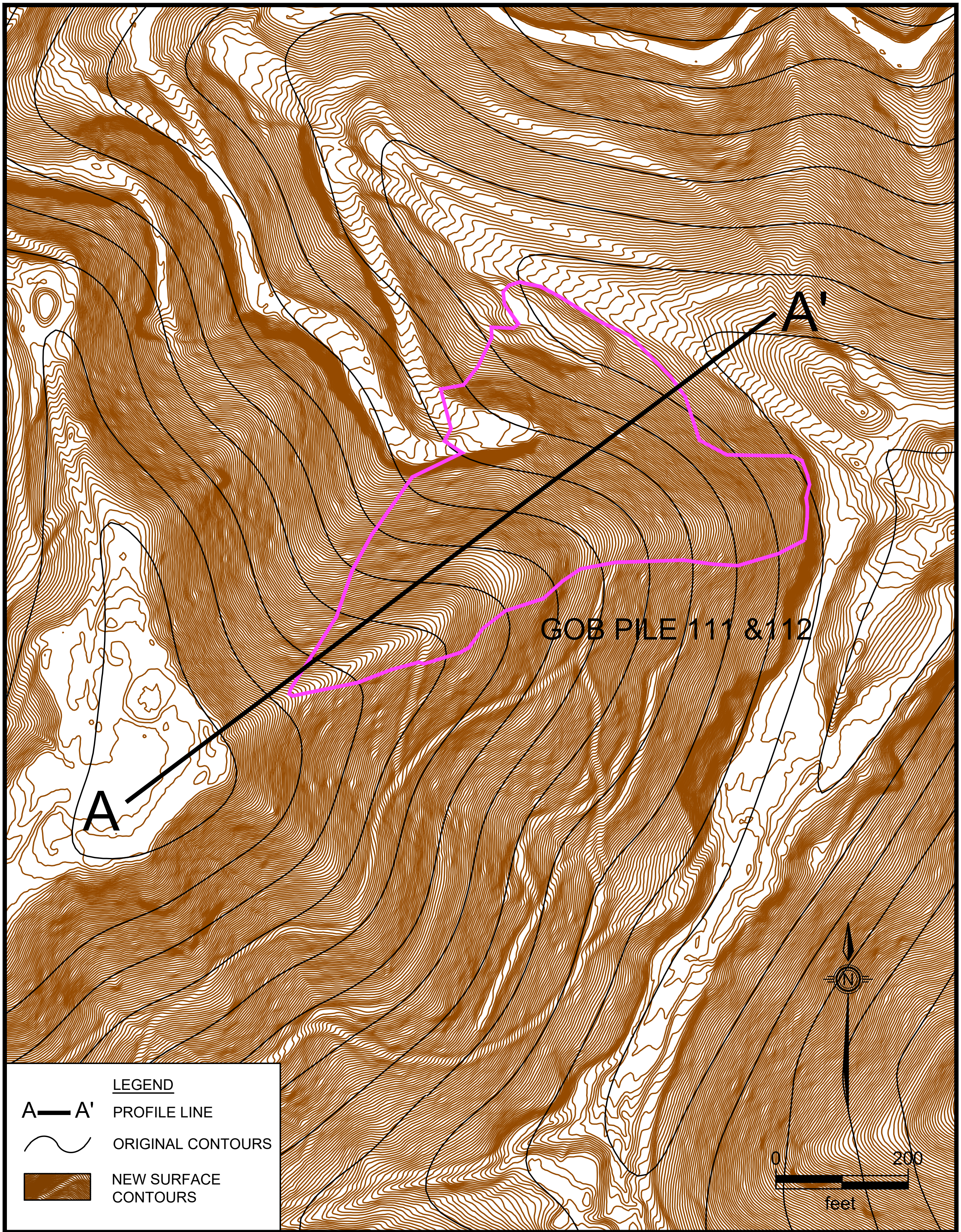
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	107 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 26C

GOB PILE 107
PROFILE A - A'

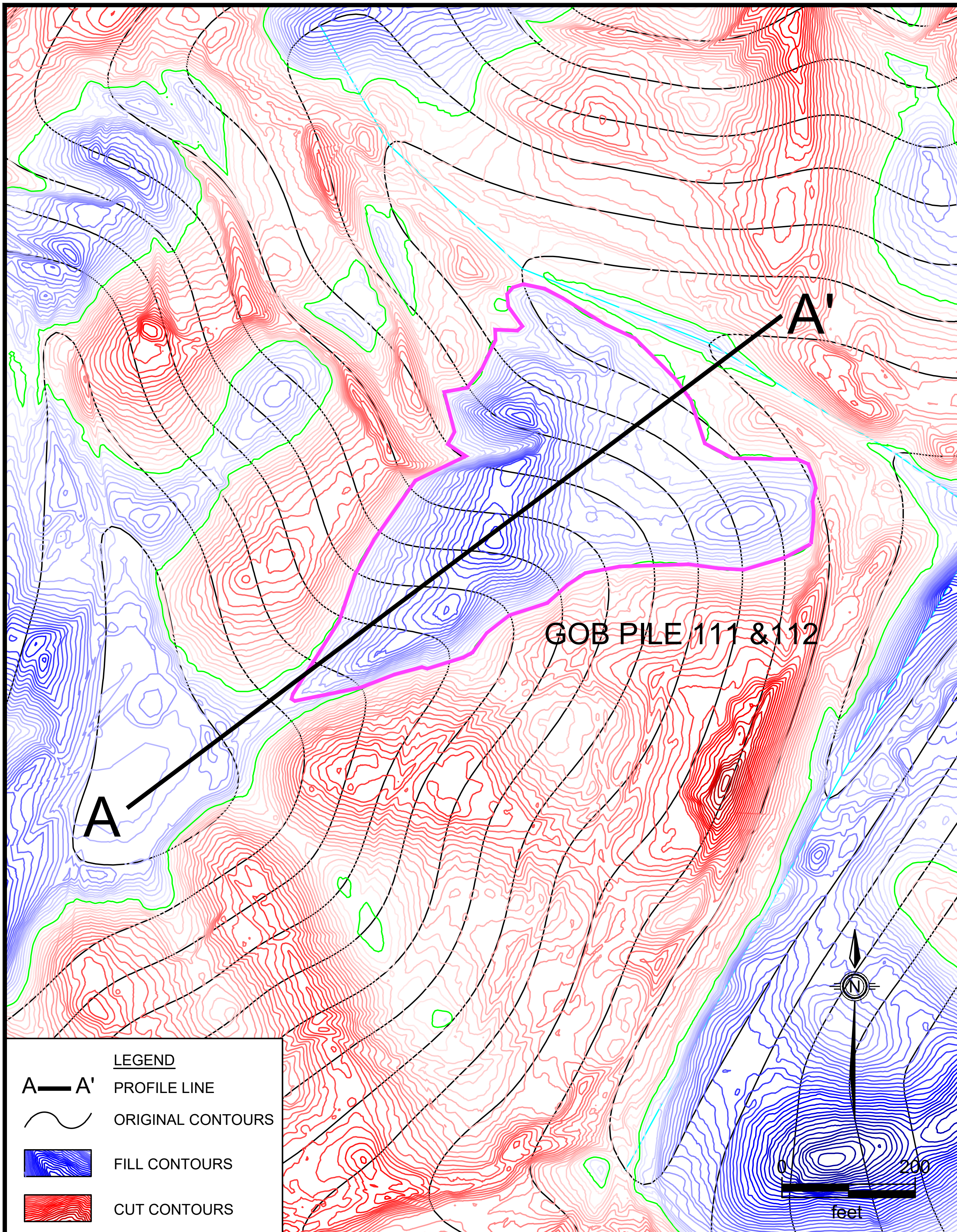


MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	111 112 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 27A
PLANVIEW
GOB PILE 111 and 112

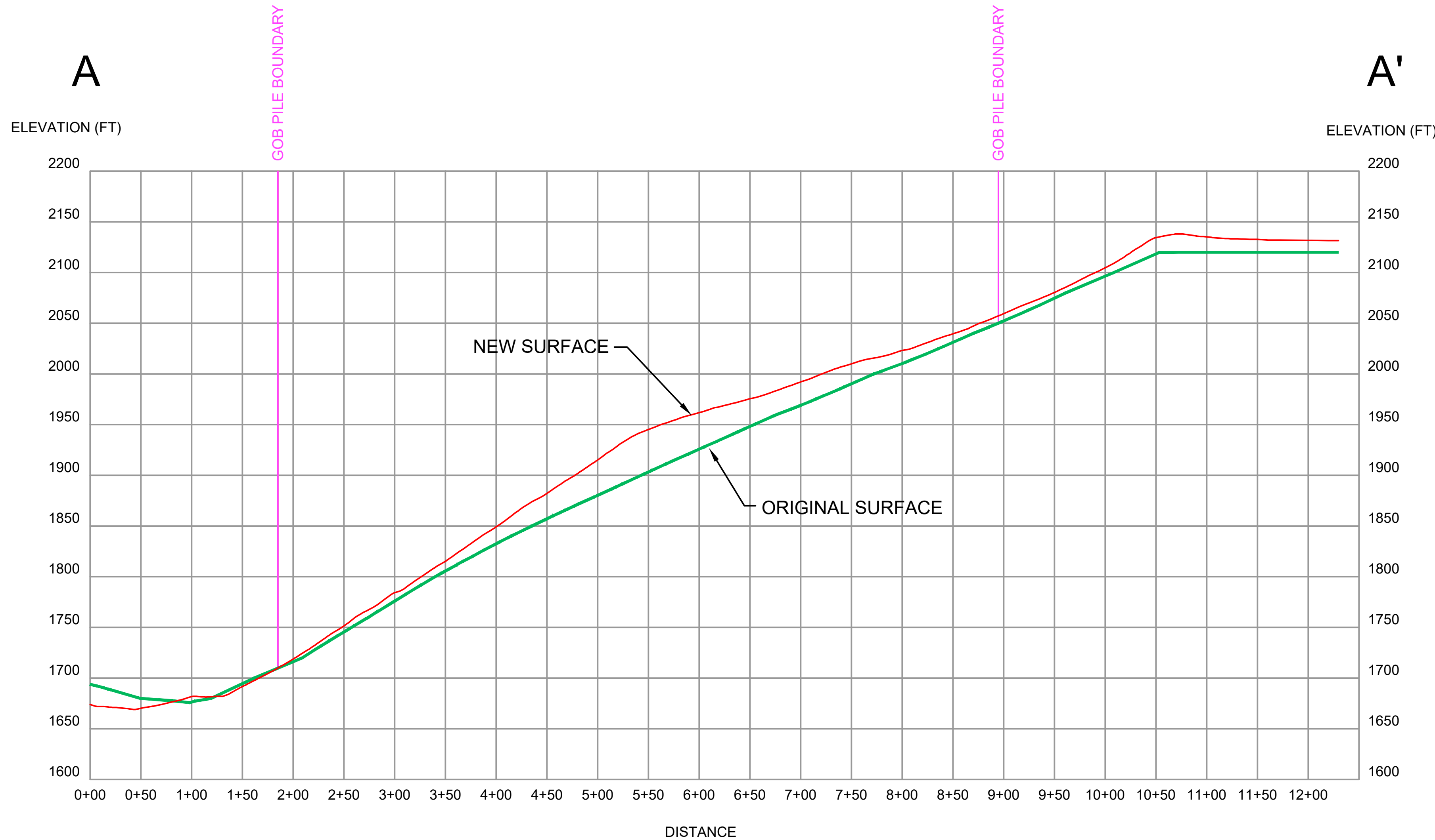


MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=200'
Project No.:	VAEN100
File No.	111 & 112 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 27B
PLANVIEW
GOB PILE 111 and 112



MARSHALL MILLER & ASSOCIATES

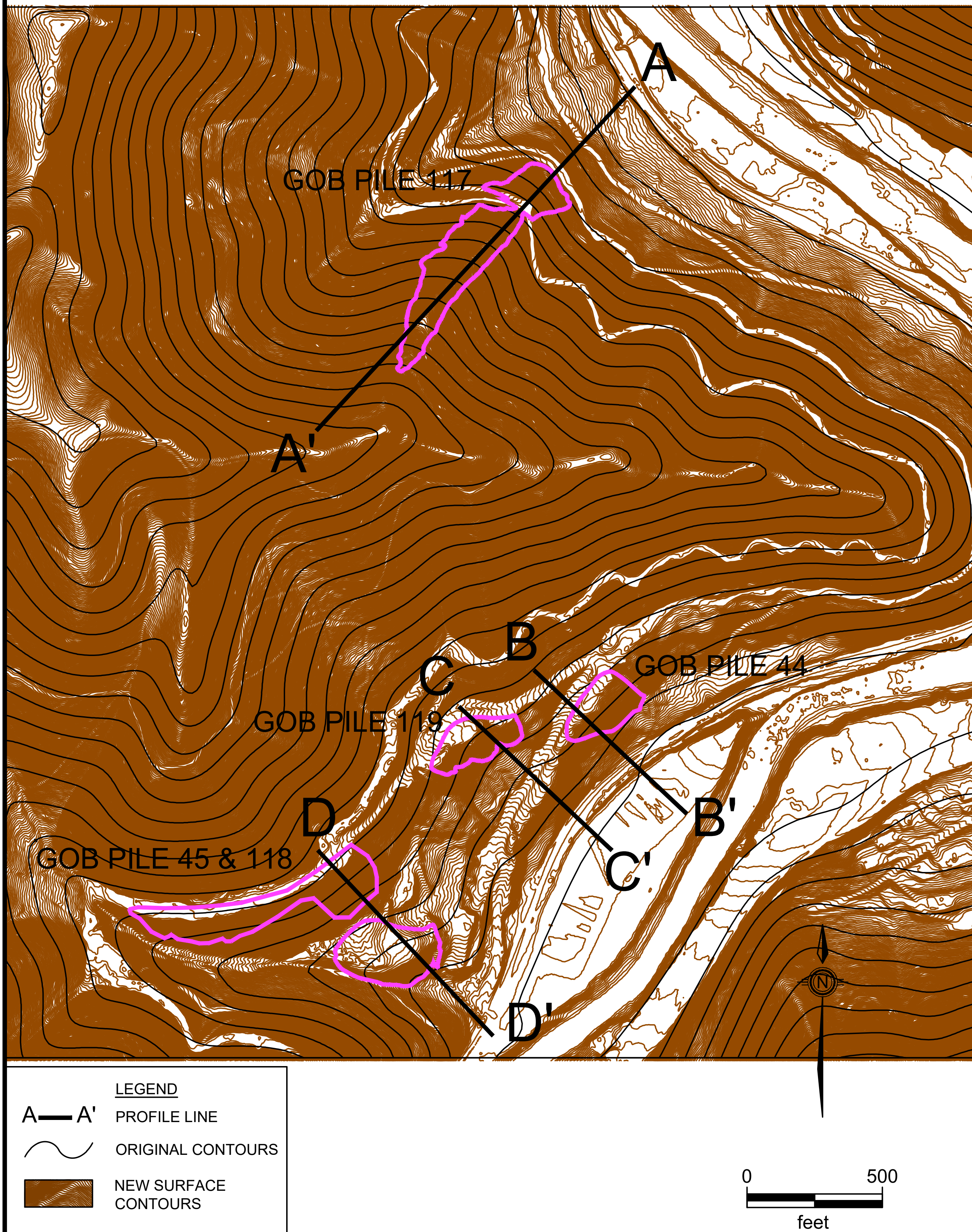
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	111 & 112 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 27C

GOB PILE 111 AND 112
PROFILE A - A'

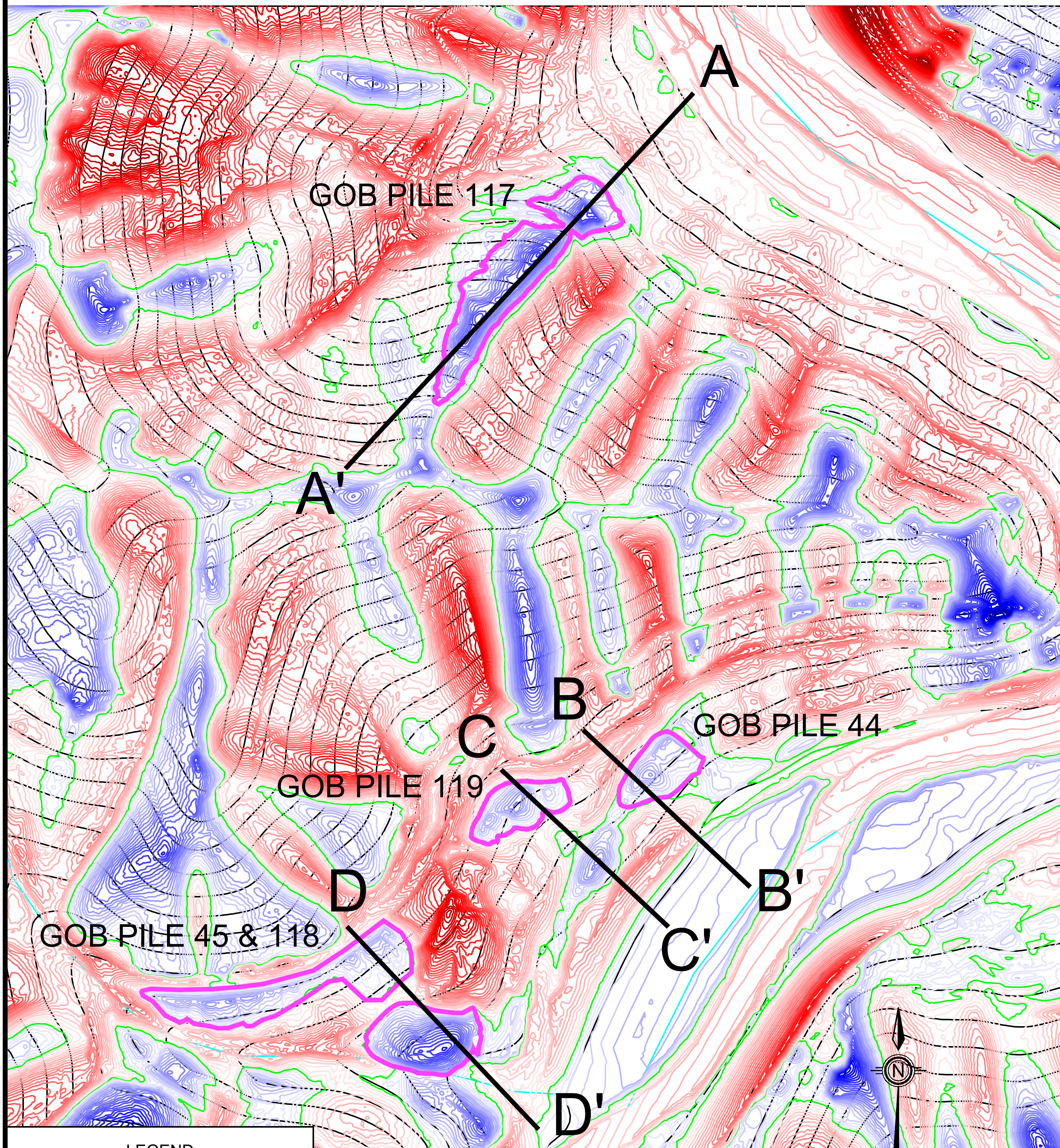


MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=500'
Project No.:	VAEN100
File No. 117-44-119-45-118 CF.dwg	

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 28A
PLANVIEW GOB PILES
117, 44, 119,45 AND 118



LEGEND

A—A' PROFILE LINE

ORIGINAL CONTOURS

FILL CONTOURS

CUT CONTOURS

0 500
feet

MARSHALL MILLER & ASSOCIATES

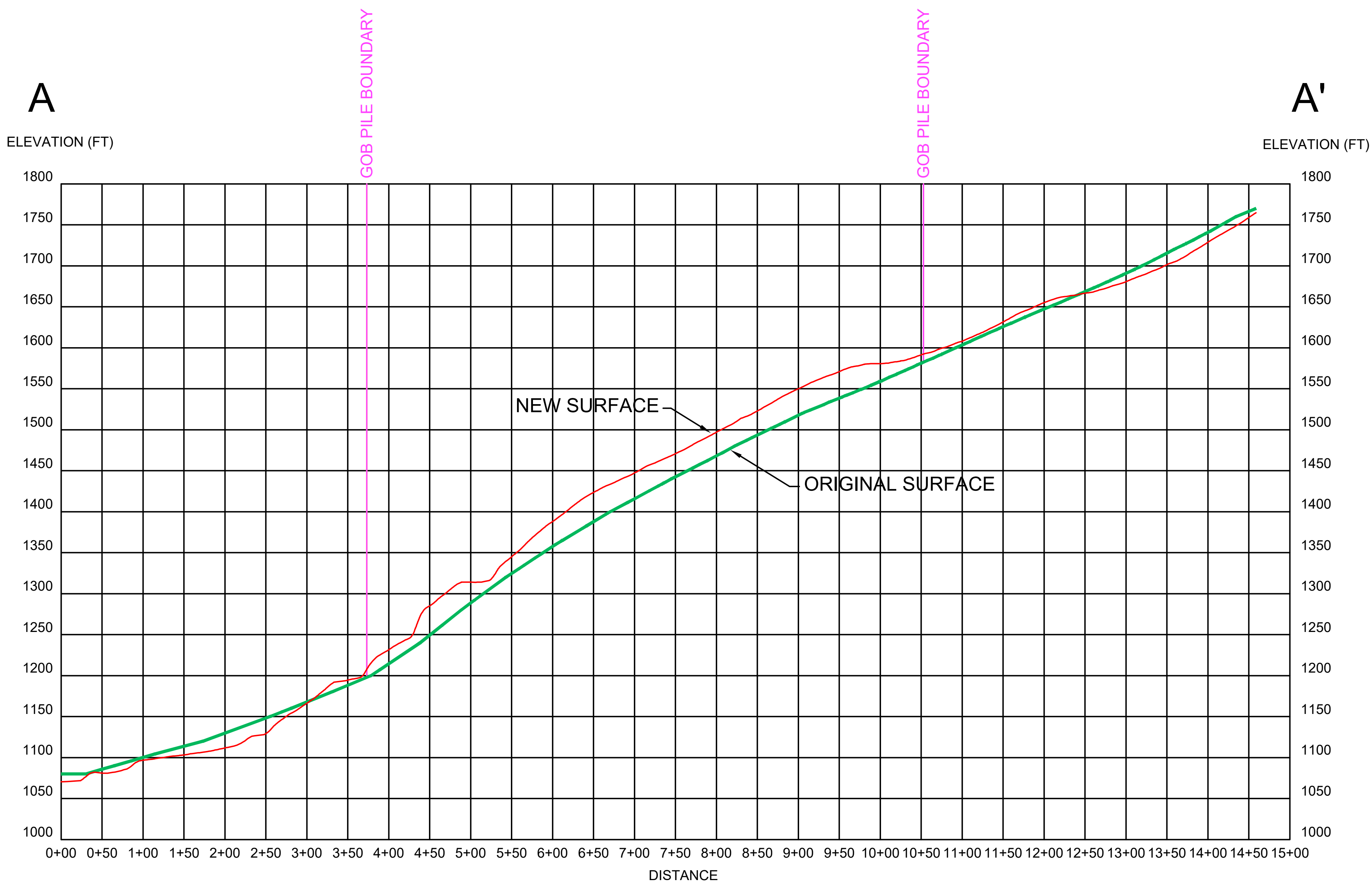
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=500'
Project No.:	VAEN100
File No. 117-44-119-45-118 CF.dwg	

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 28B

PLANVIEW GOB PILES
117, 44, 119,45 AND 118



MARSHALL MILLER & ASSOCIATES

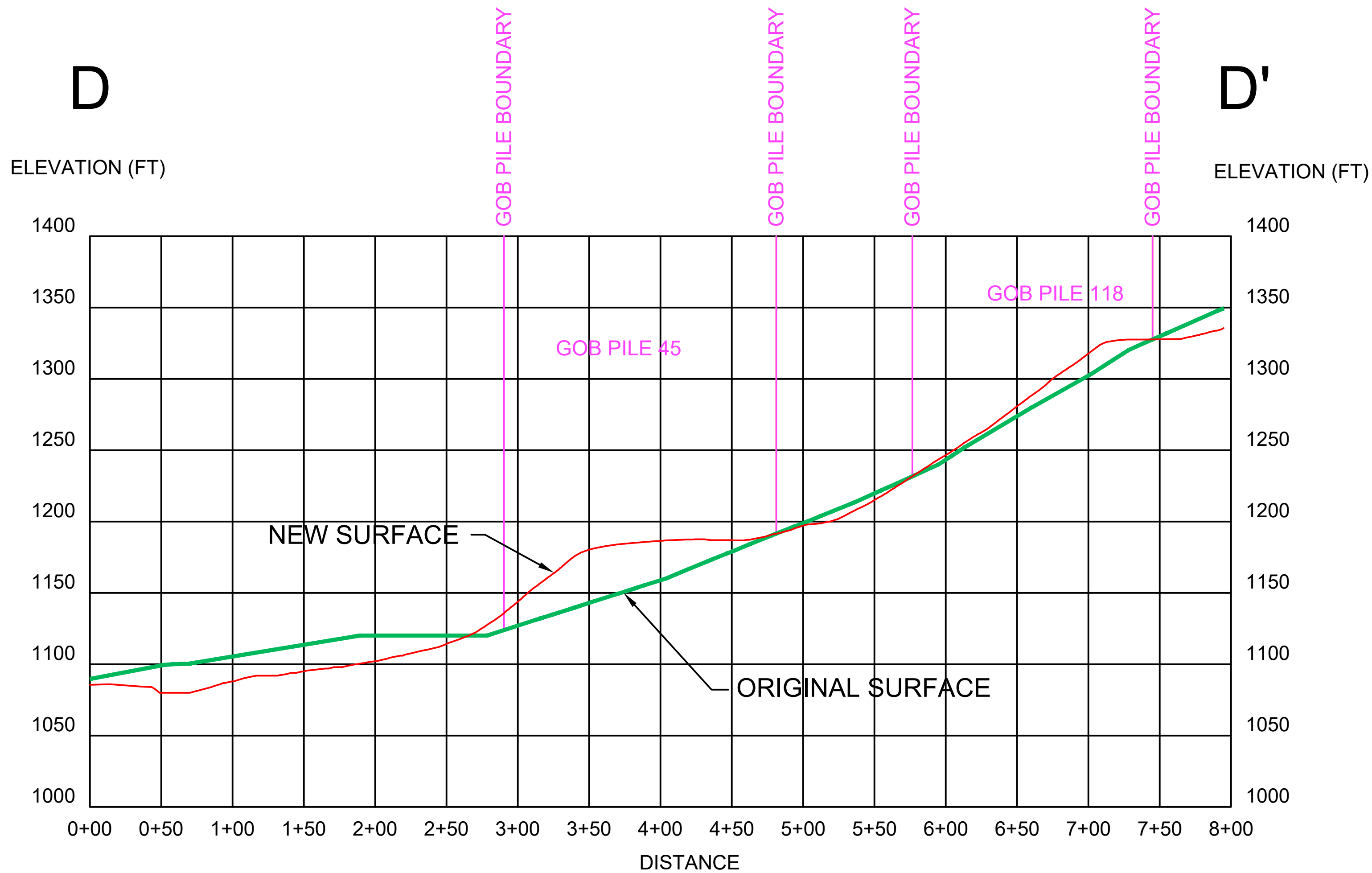
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	117-44-119-45-118 CF.dwg

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 28C

GOB PILE 117
PROFILE A - A'



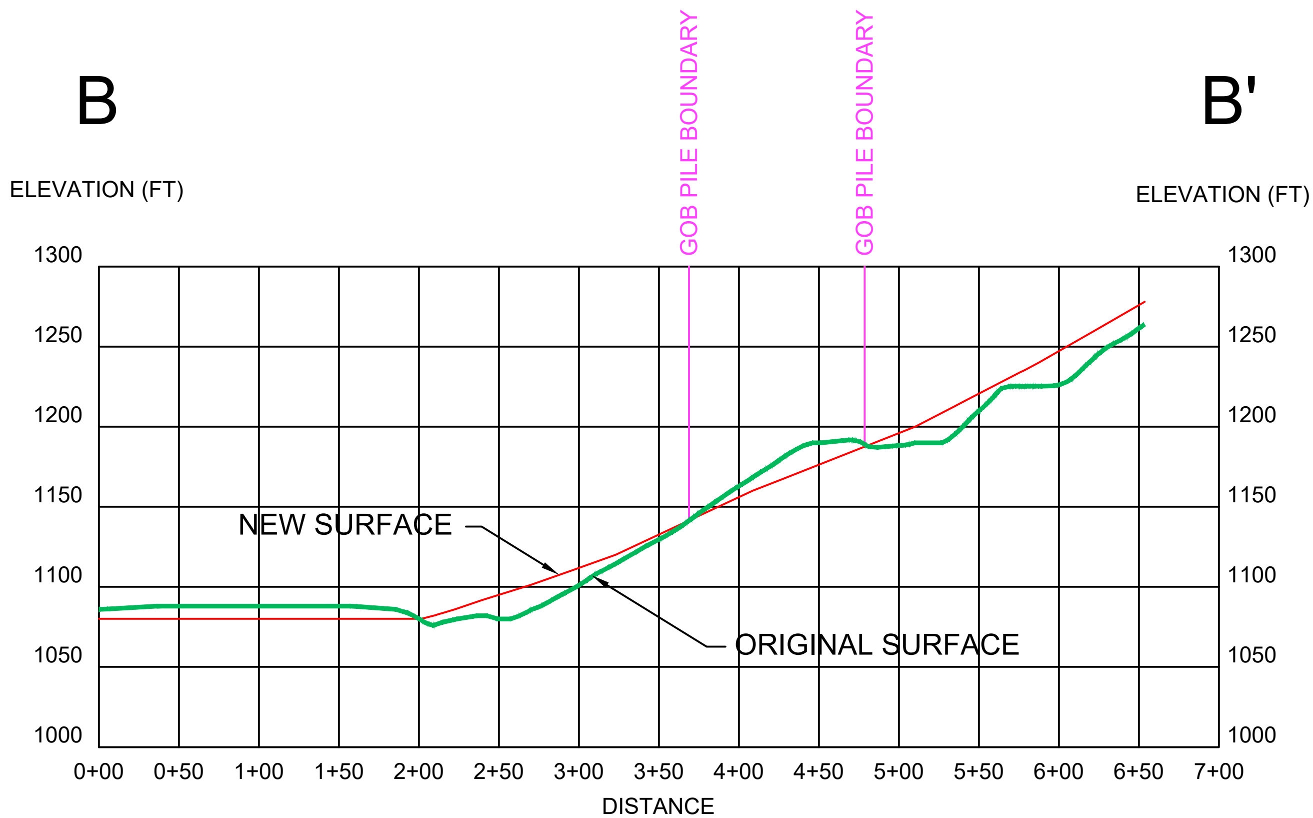
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	117-44-119-45-118 CF.dwg

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 28D

GOB PILE 45 &118
PROFILE D - D'



MARSHALL MILLER & ASSOCIATES

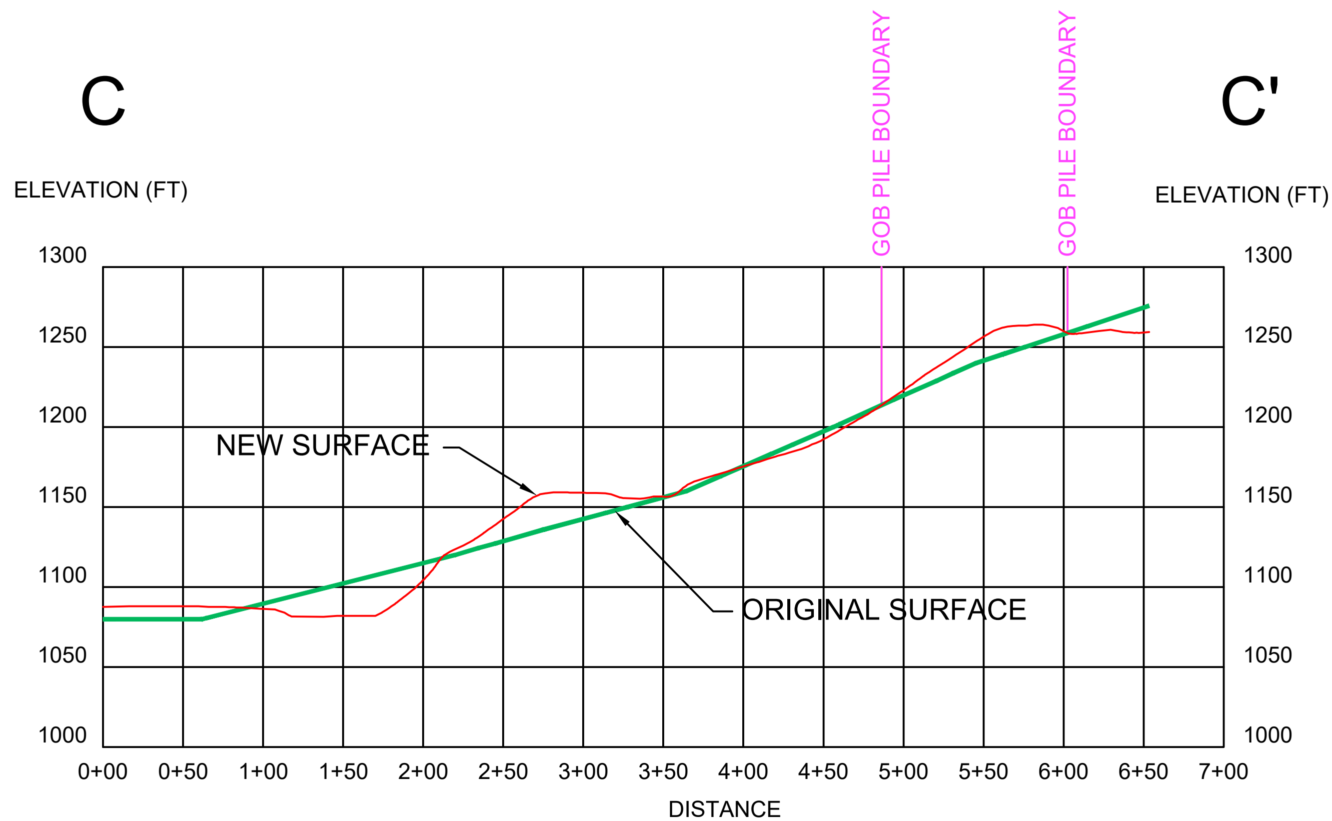
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	117-44-119-45-118 CF.dwg

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 28E

GOB PILE 44
PROFILE B - B'



MARSHALL MILLER & ASSOCIATES

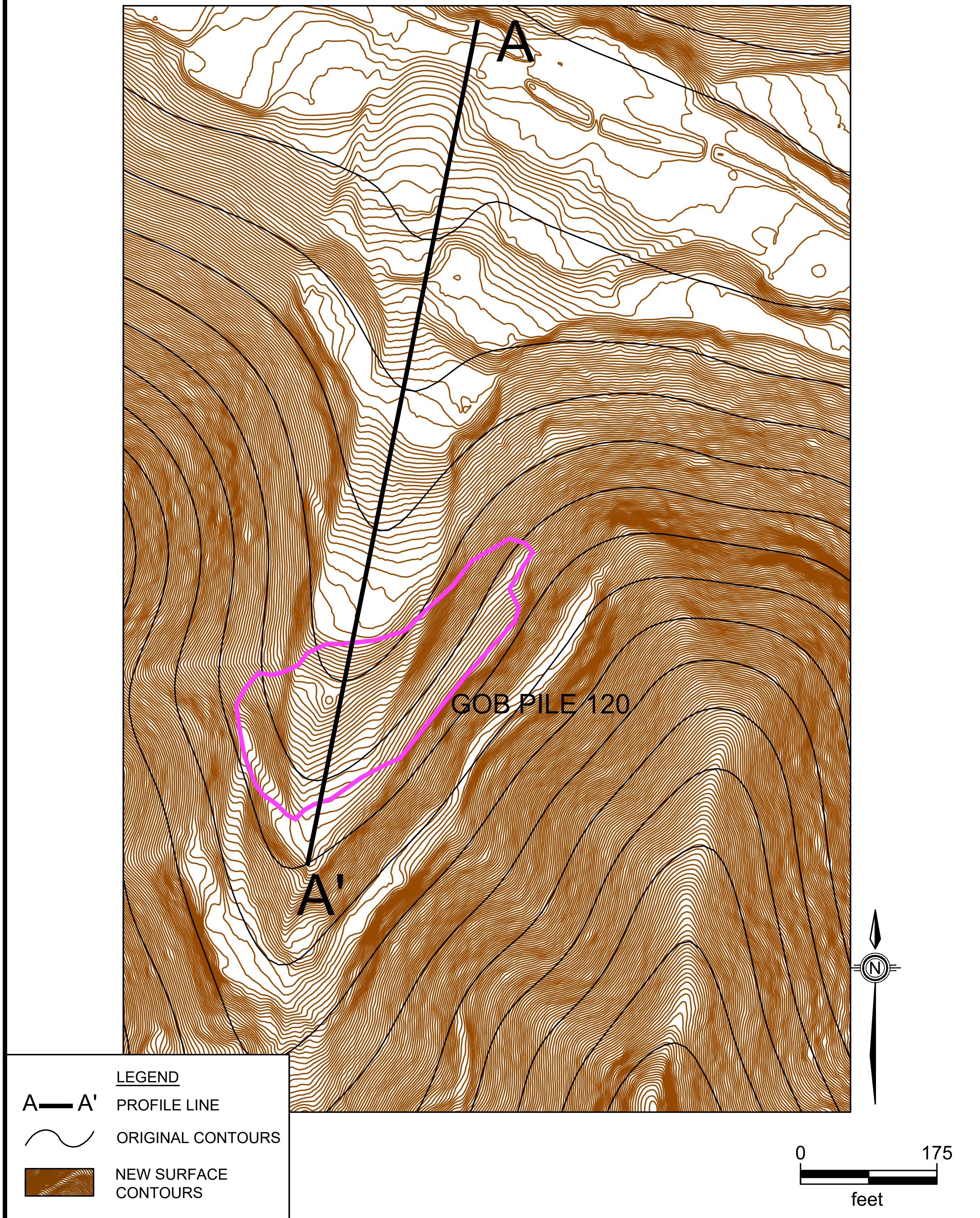
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	117-44-119-45-118 CF.dwg

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 28F

GOB PILE 119
PROFILE C - C'

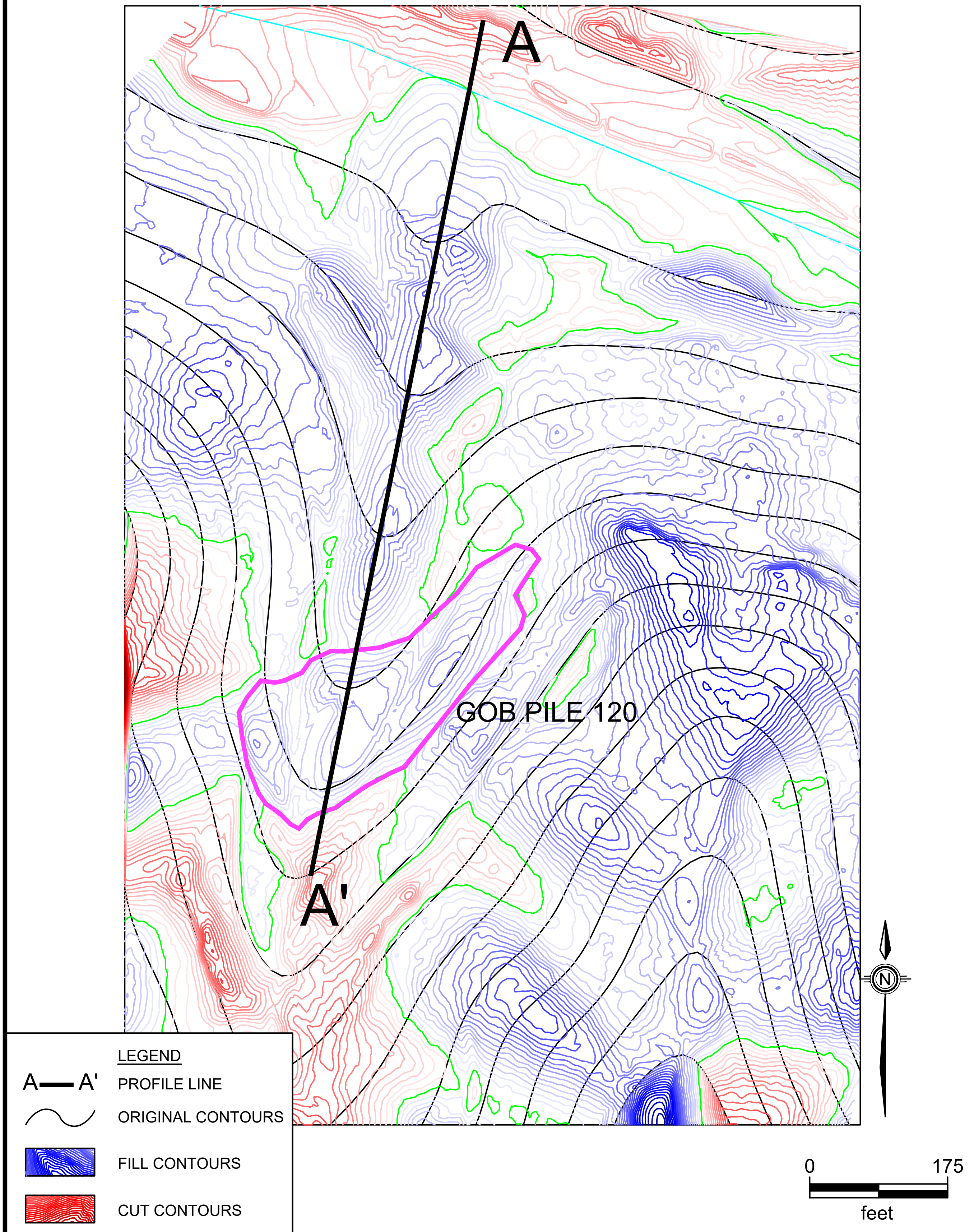


MARSHALL MILLER & ASSOCIATES

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=175'
Project No.:	VAEN100
File No.	120 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 29A
PLANVIEW
GOB PILE 120

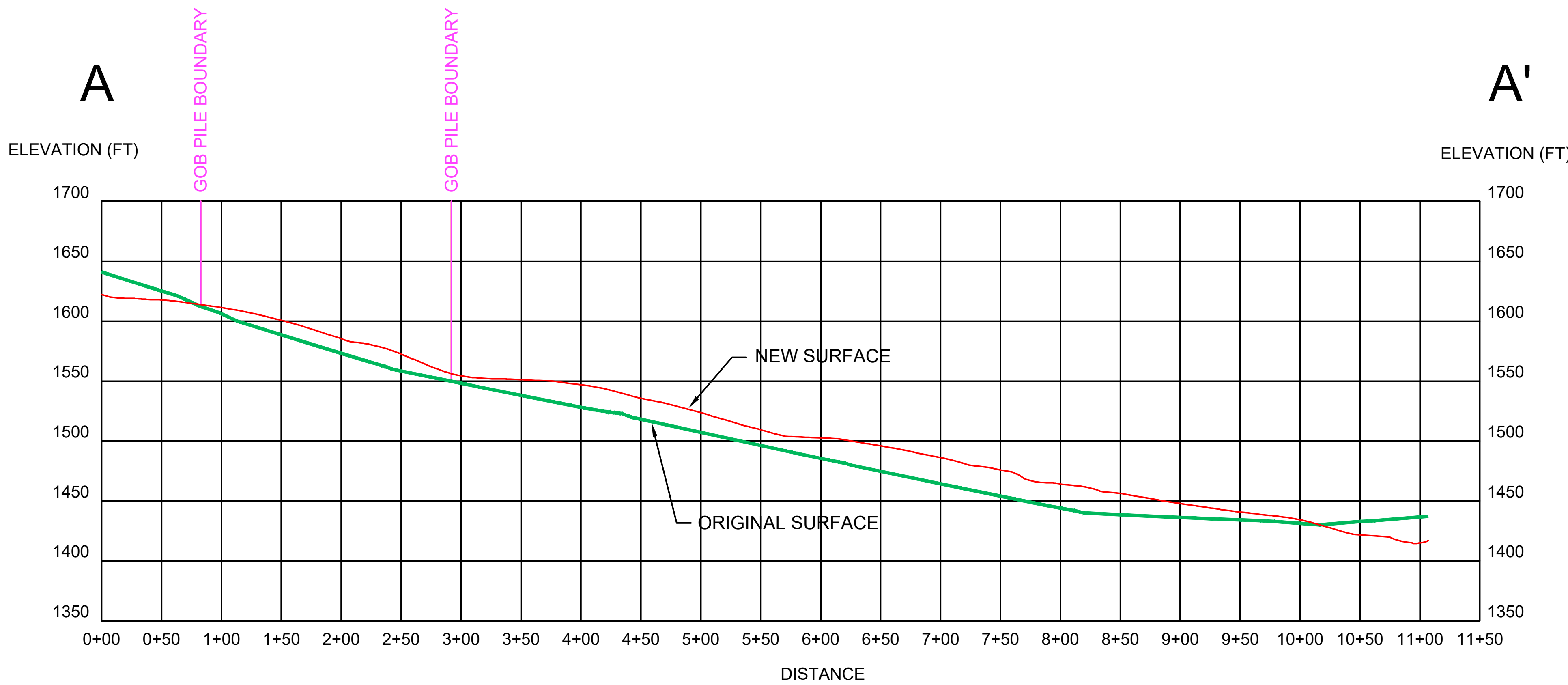


Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=175'
Project No.:	VAEN100
File No.	120 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 29B

PLANVIEW
GOB PILE 120



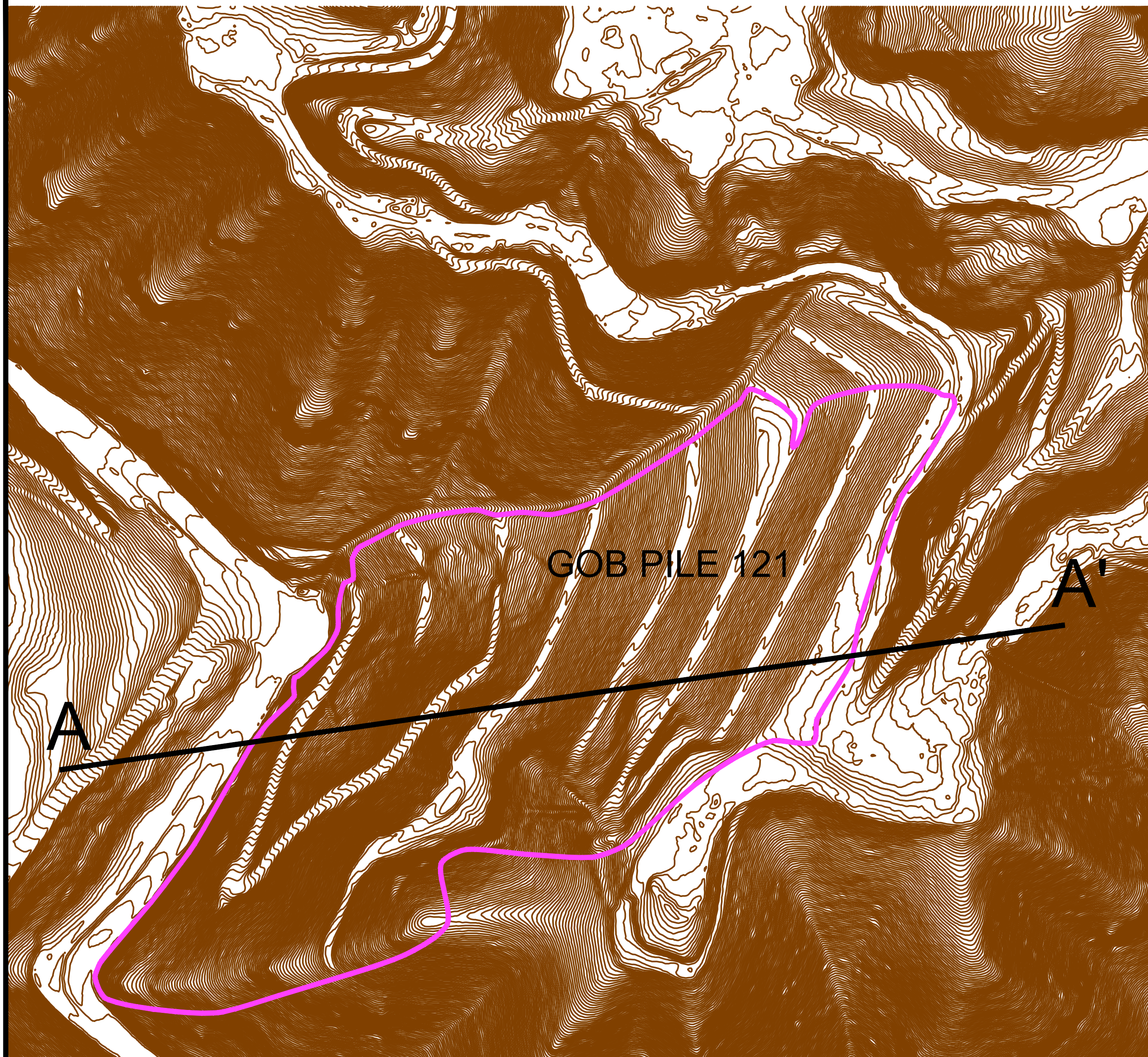
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	120 CF.DWG

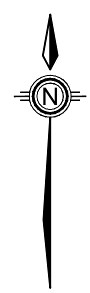
Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

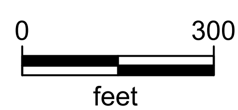
Big Stone Gap, Virginia

Exhibit 29C

GOB PILE 120
PROFILE A - A'







LEGEND

A—A' PROFILE LINE

ORIGINAL CONTOURS

NEW SURFACE CONTOURS

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	121 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
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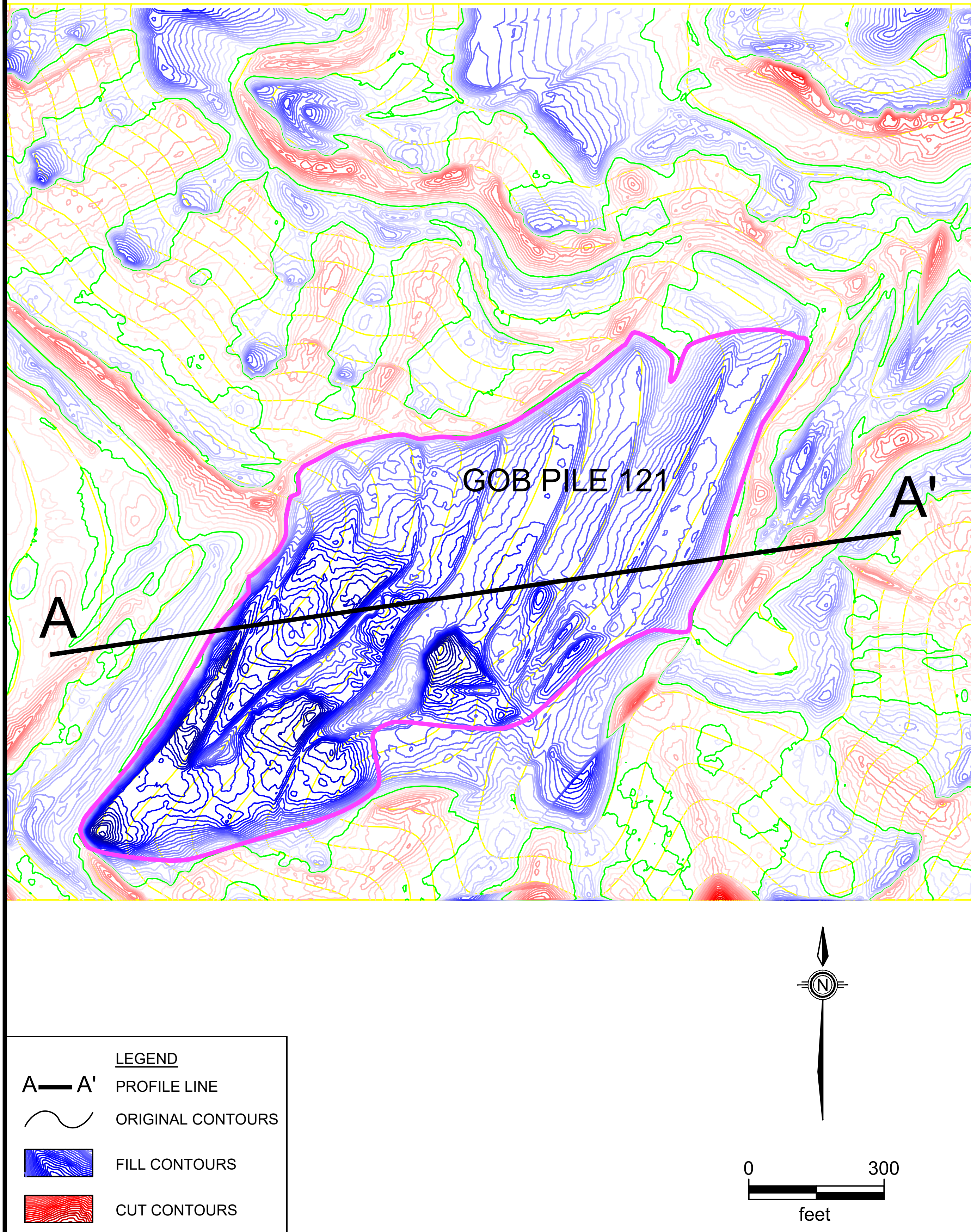
Big Stone Gap, Virginia

Exhibit 30A

PLANVIEW
GOB PILE 121



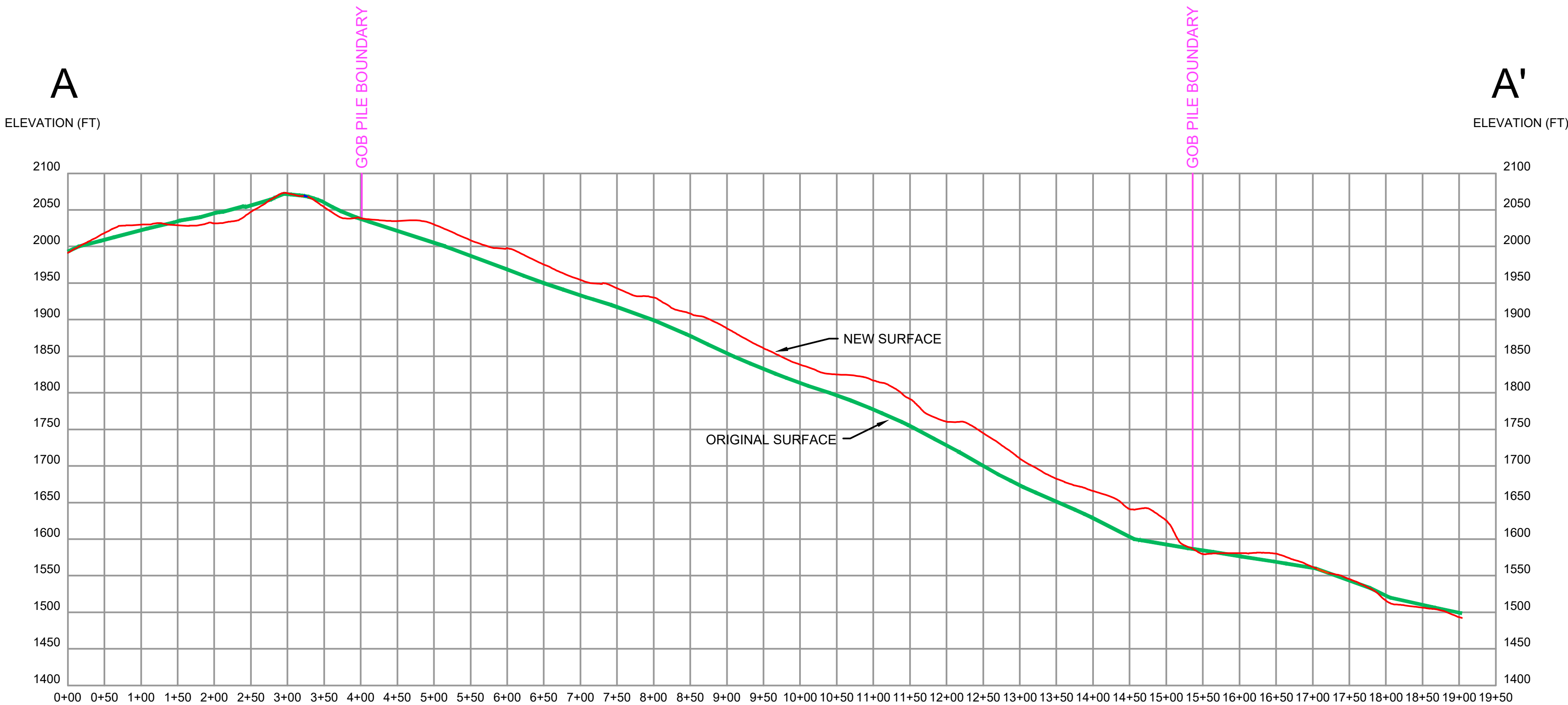
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=300'
Project No.:	VAEN100
File No.	121 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 30B

PLANVIEW
GOB PILE 121



MARSHALL MILLER & ASSOCIATES

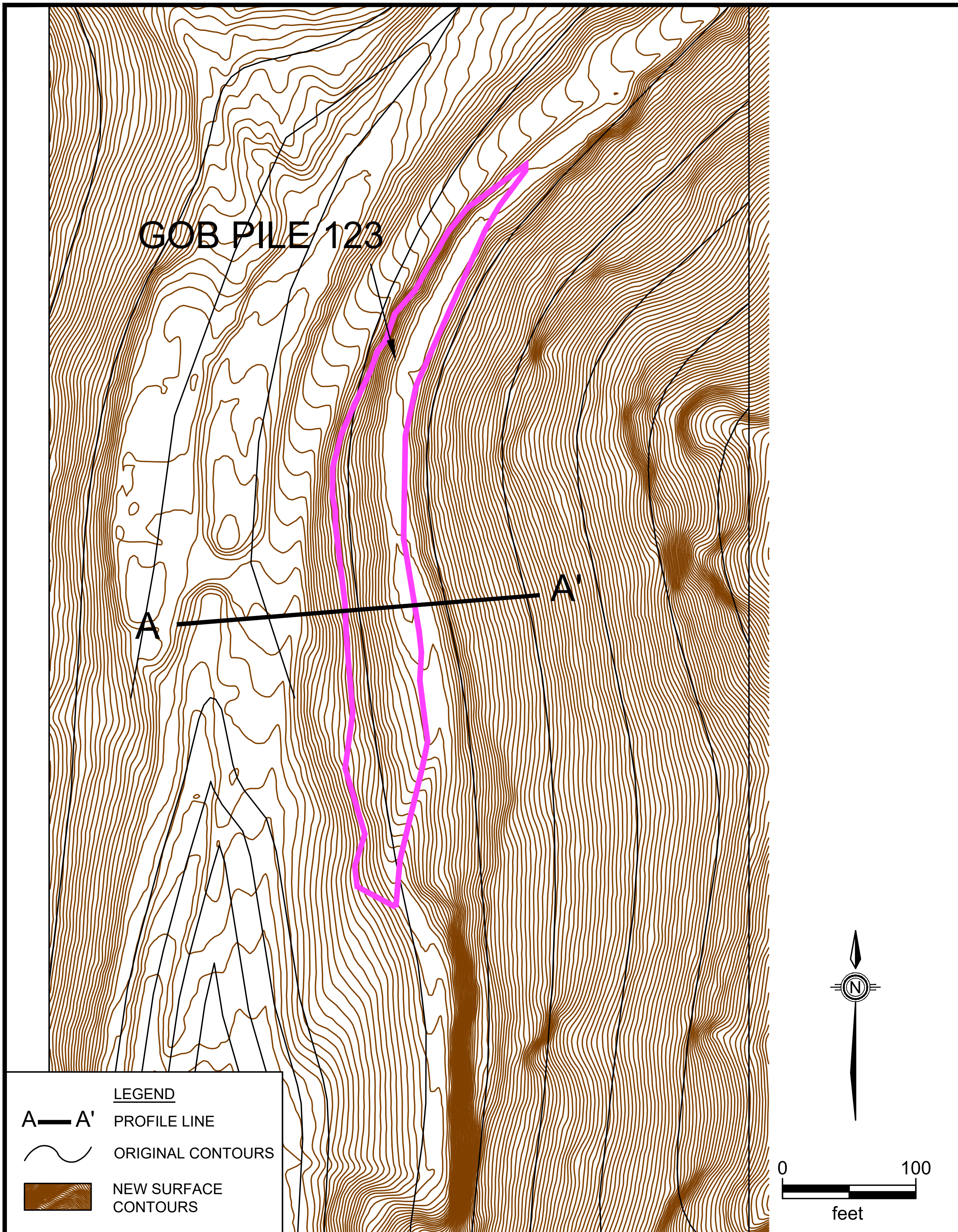
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	121 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 30C

GOB PILE 121
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES

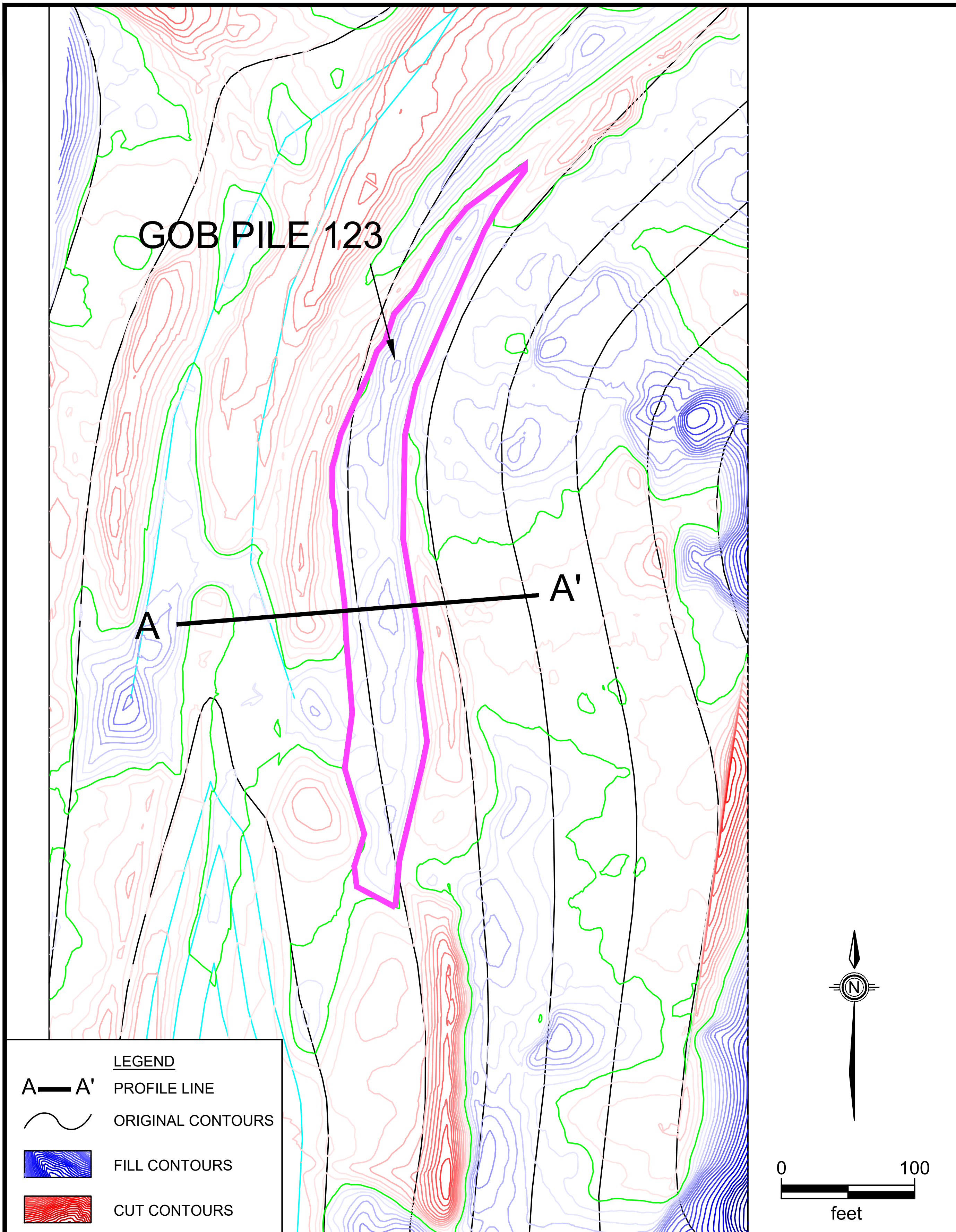
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=100'
Project No.:	VAEN100
File No.	123 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services

Big Stone Gap, Virginia

Exhibit 31A

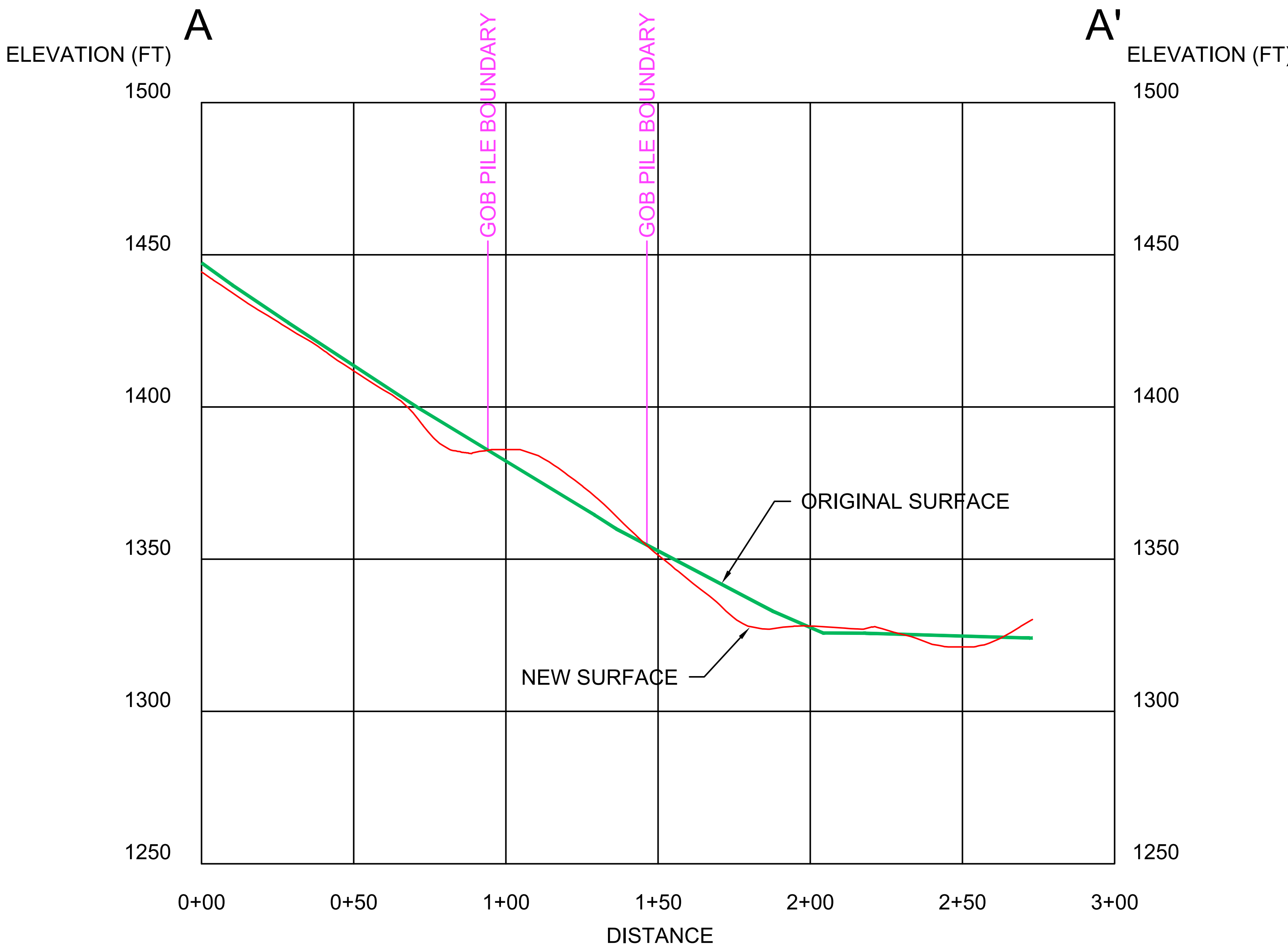
PLANVIEW
GOB PILE 123



Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	1"=100'
Project No.:	VAEN100
File No.	123 CF.DWG

Virginia Department Of Energy
Waste Coal Piles
Research Consulting Services
Big Stone Gap, Virginia

Exhibit 31B
PLANVIEW
GOB PILE 123



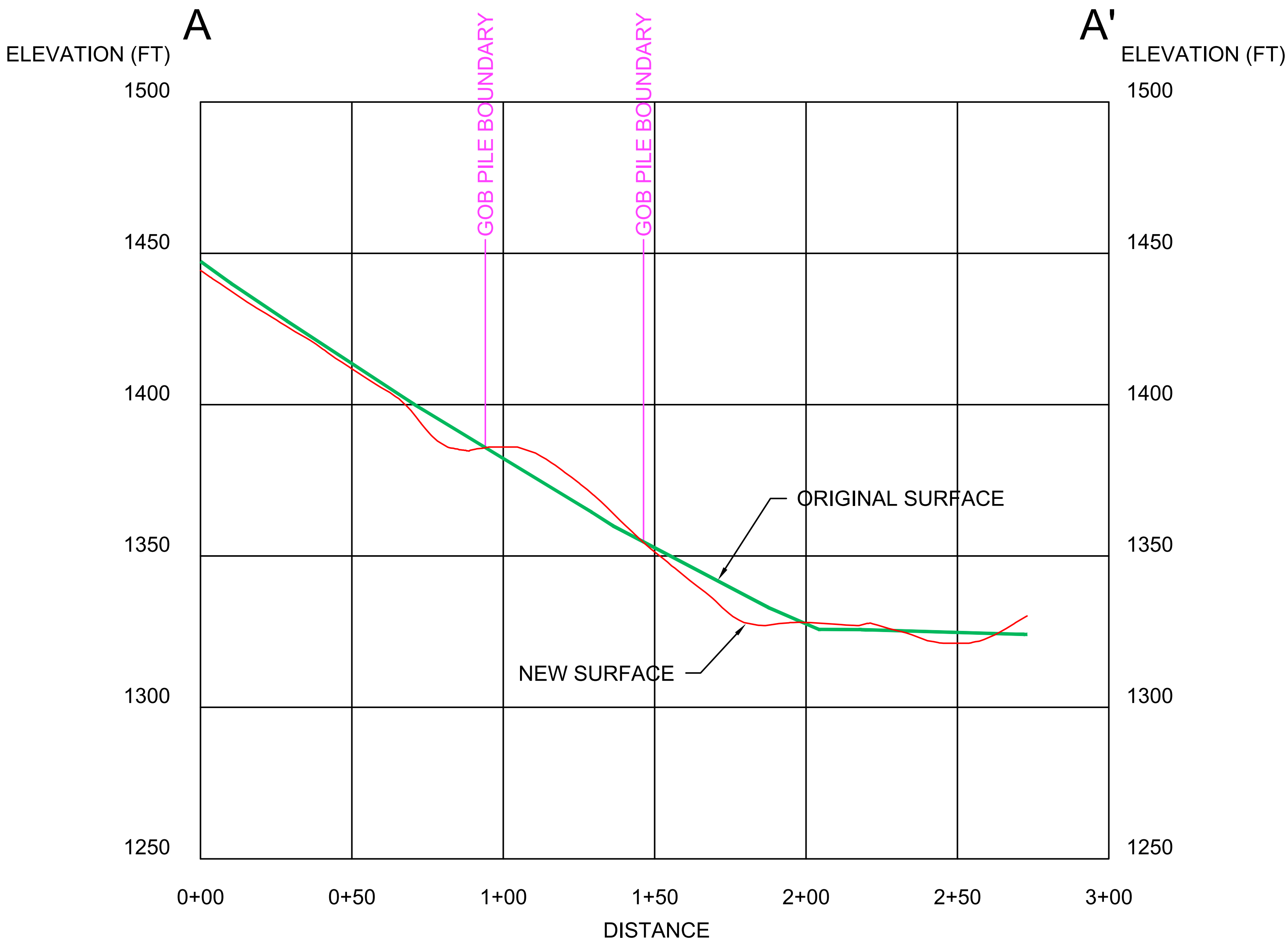
Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	XXXXX
File No.	123 CF.DWG

Company
Project

Place, State

Exhibit 31C

GOB PILE 123
PROFILE A - A'



MARSHALL MILLER & ASSOCIATES®

Drawn:	SA
Checked:	SA
Date:	9/2022
Scale:	AS SHOWN
Project No.:	VAEN100
File No.	123 CF.DWG

Virginia Department Of Energy
Waste Coal Piles Research Consulting Services

Big Stone Gap, Virginia

Exhibit 31D

GOB PILE 123
PROFILE A - A'

APPENDIX

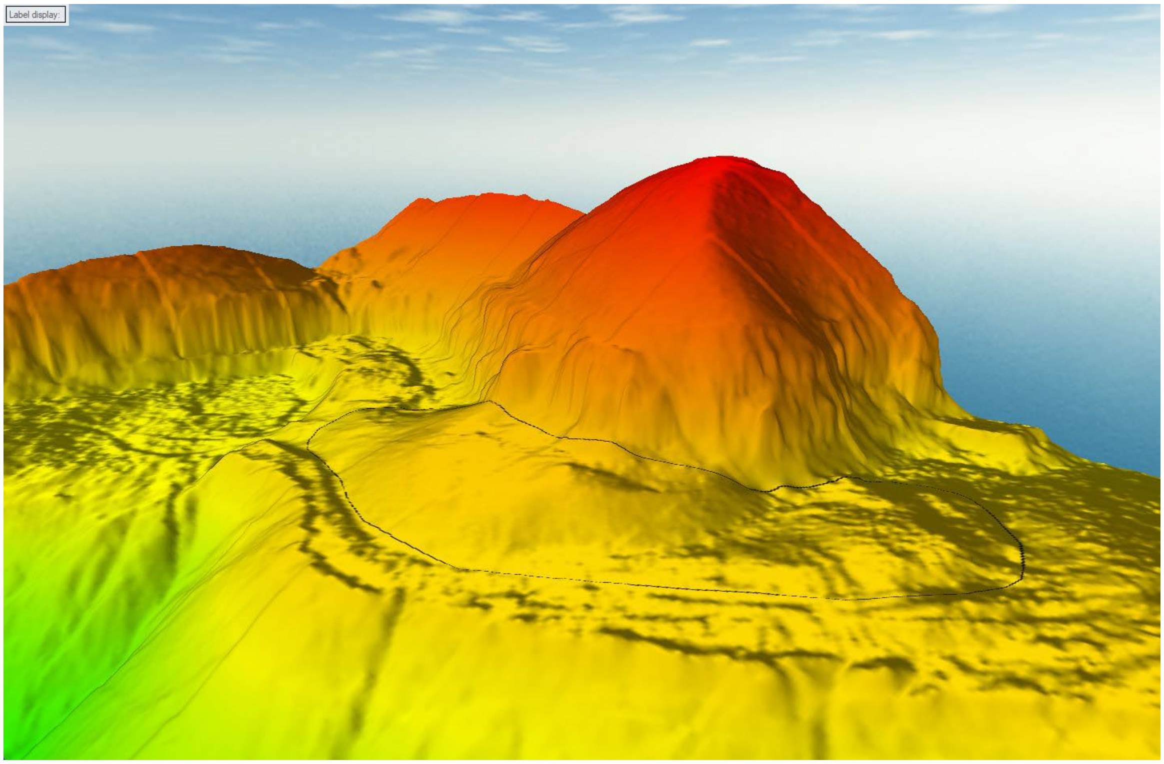
4

SUPPORTING INFORMATION, VA ENERGY (WISE, DICKENSON, LEE COUNTIES)

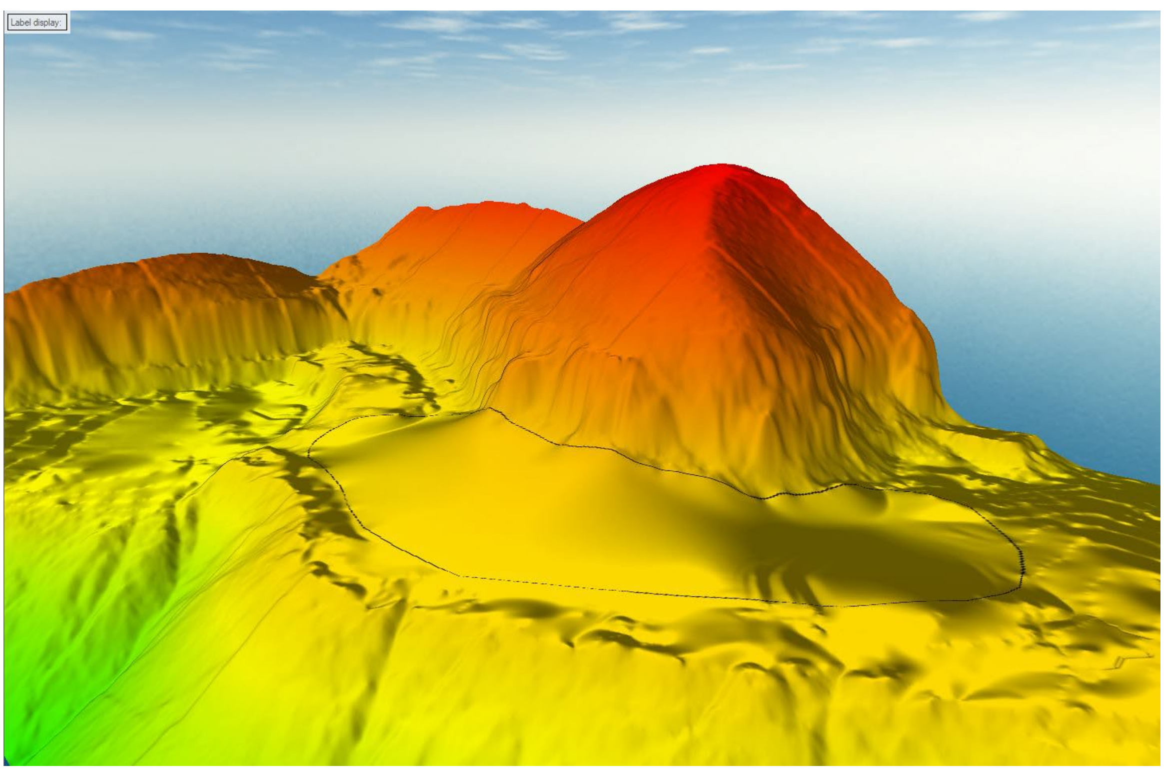
MARSHALL MILLER & ASSOCIATES ®

Unique ID: CBC_51622705

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

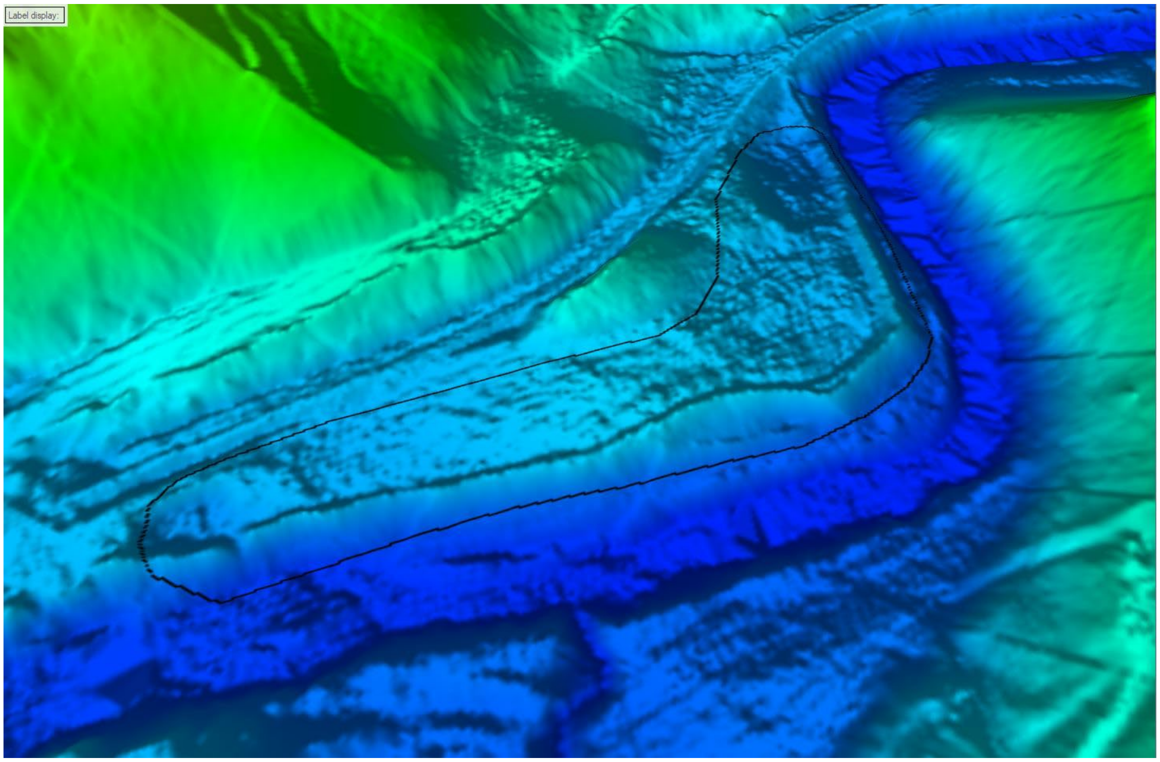
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

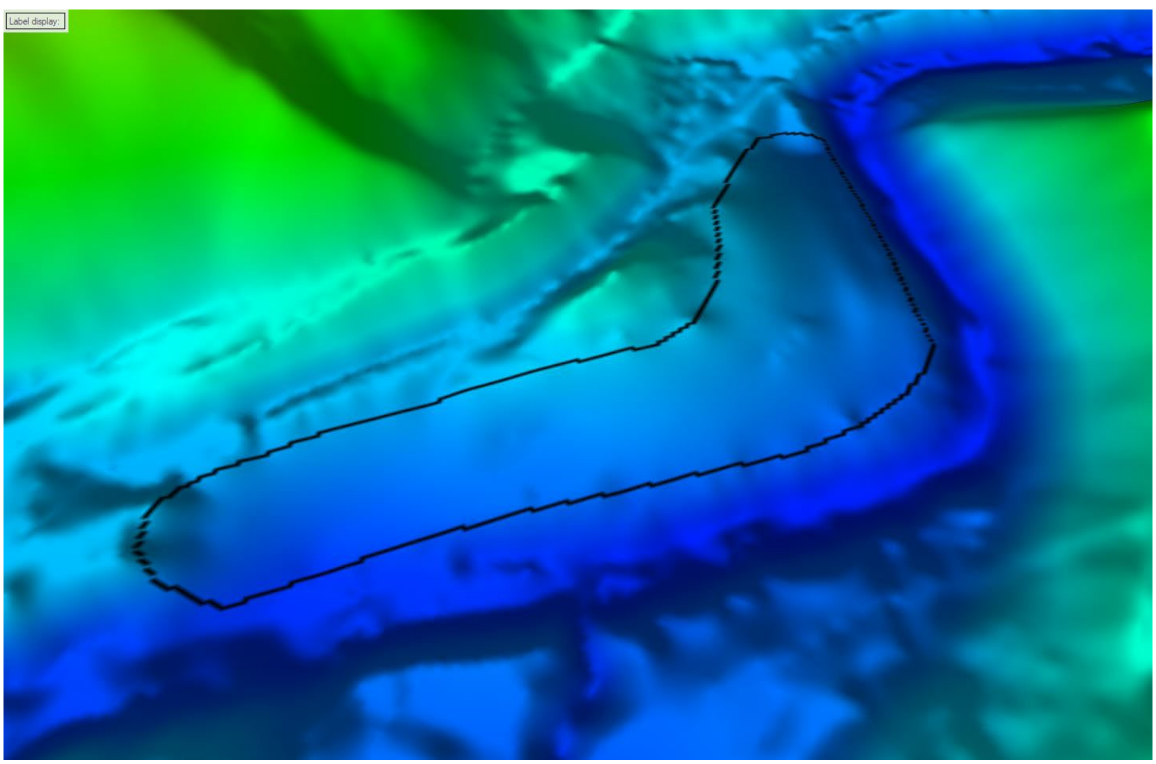
OBJECTID *	Value	Count	AREA	VOLUME
1	1	7906	85099.14	367487.2904
2	2	1	10.76387	-0.788369
3	3	10	107.6387	-101.628672
4	4	6	64.5832	-7.987494
5	5	1	10.76387	-6.822021
6	6	1	10.76387	-1.466367
7	7	2	21.52774	-5.61713
8	8	3	32.2916	-9.582628
9	9	3	32.2916	-2.771118
10	10	3	32.2916	-13.739961
11	11	12	129.1664	-52.431807
12	12	104	1119.442	-407.237362
13	13	2	21.52774	-0.752893
14	14	6	64.5832	-25.180512
15	15	3	32.2916	4.508158
16	16	7	75.34707	-21.413421
17	17	42	452.0824	-227.728325
18	18	3	32.2916	3.241511
19	19	1	10.76387	-0.370534
20	20	13	139.9303	-27.008215
21	21	355	3821.173	-1873.18228
22	22	1	10.76387	1.089263
23	23	1	10.76387	-0.880346
24	24	1	10.76387	0.892171
25	25	1	10.76387	-0.889543
26	26	13	139.9303	-39.632633
27	27	1	10.76387	-0.898741
28	28	10	107.6387	-14.985584
29	29	3	32.2916	-3.752637
30	30	1	10.76387	-0.178697
				364650.0942 CF
				13505.55904 CY

Unique ID: CBC_51722100

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

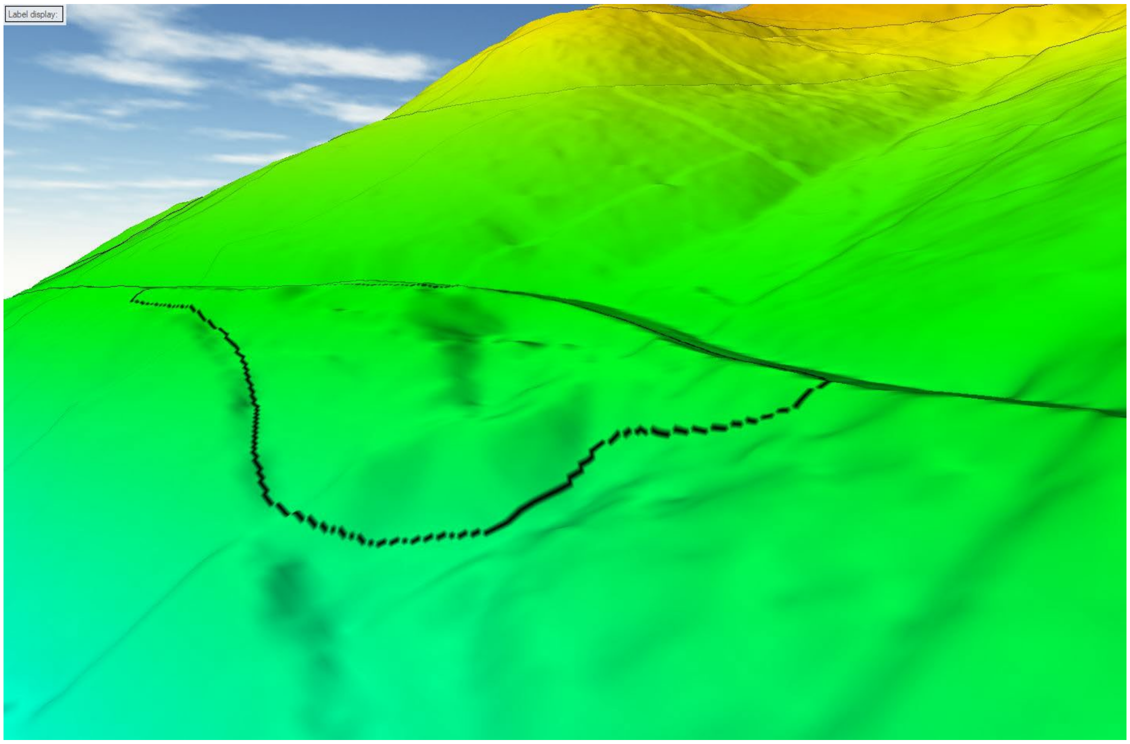
5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

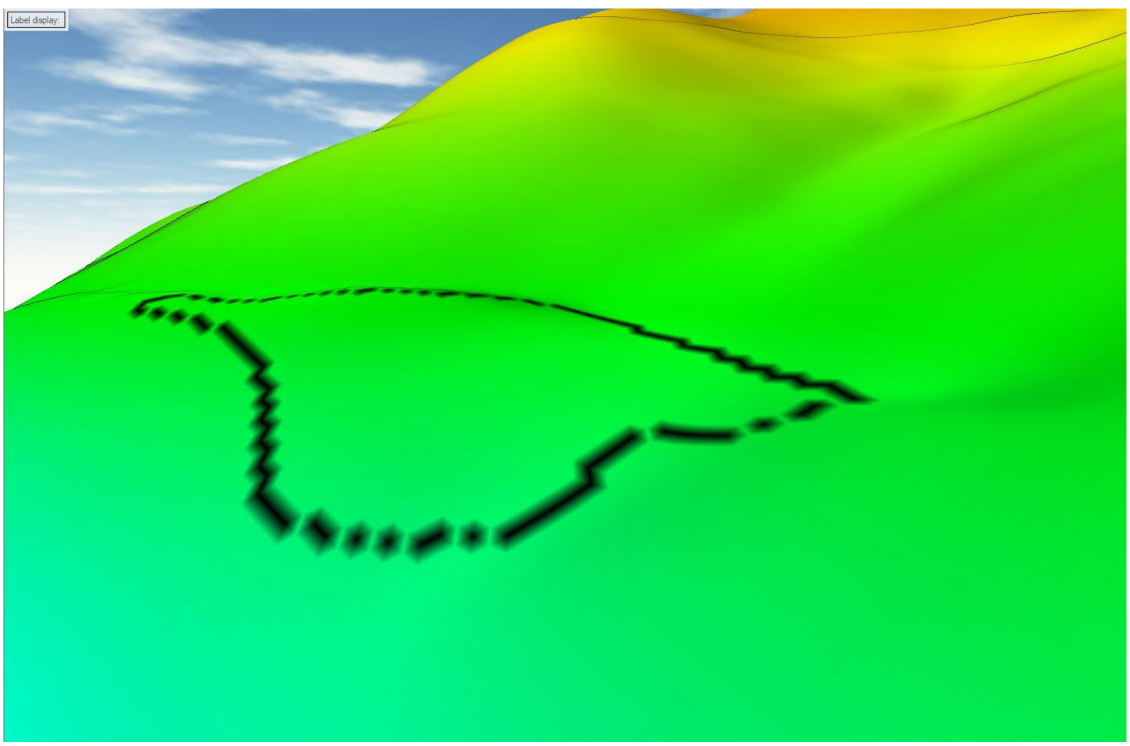
OBJECTID *	Value	Count	AREA	VOLUME
1	1	3388	84700	452053.9642
2	2	138	3450	-2533.493042
3	3	1	25	-1.074219
4	4	2	50	-1.342773
5	5	6	150	-45.059204
6	6	36	900	-189.13269
7	7	1	25	-9.024048
8	8	2	50	10.015869
9	9	1	25	-0.366211
10	10	2	50	-1.690674
11	11	1	25	-0.335693
12	12	27	675	-888.024902
13	13	3	75	-6.207275
14	14	1	25	-7.788086
15	15	6	150	-33.520508
				448346.9208 CF
				16605.44151 CY

Unique ID: CBC_60922556

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

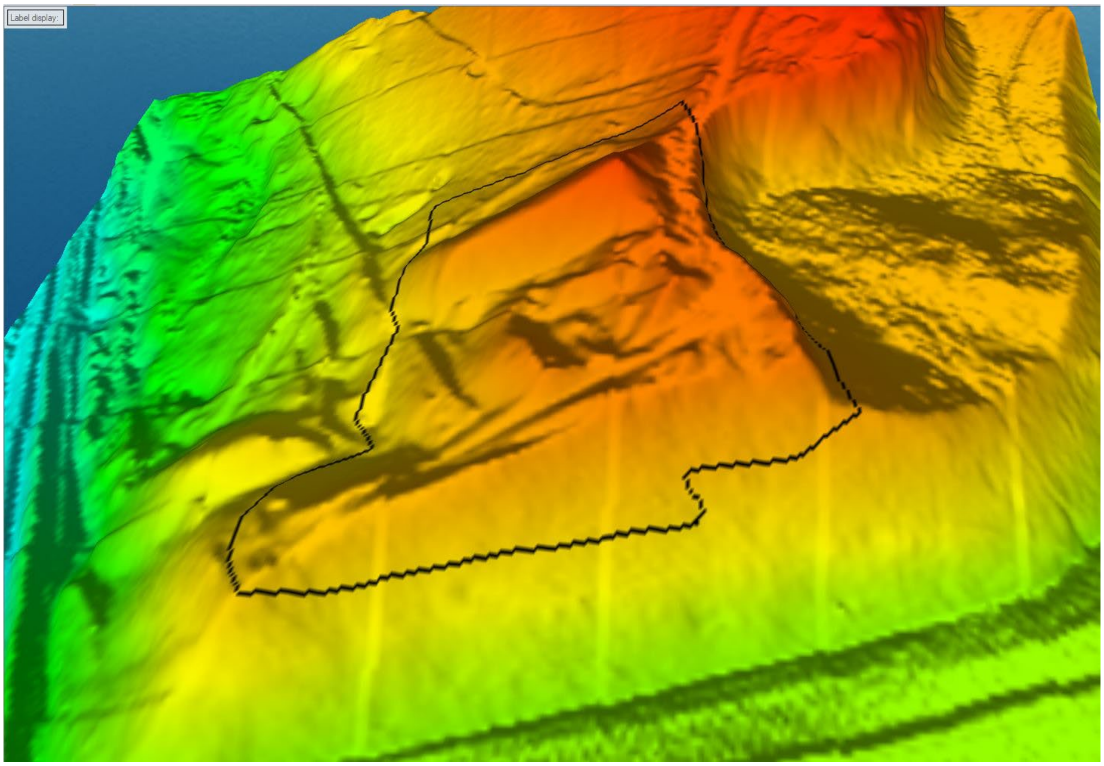
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

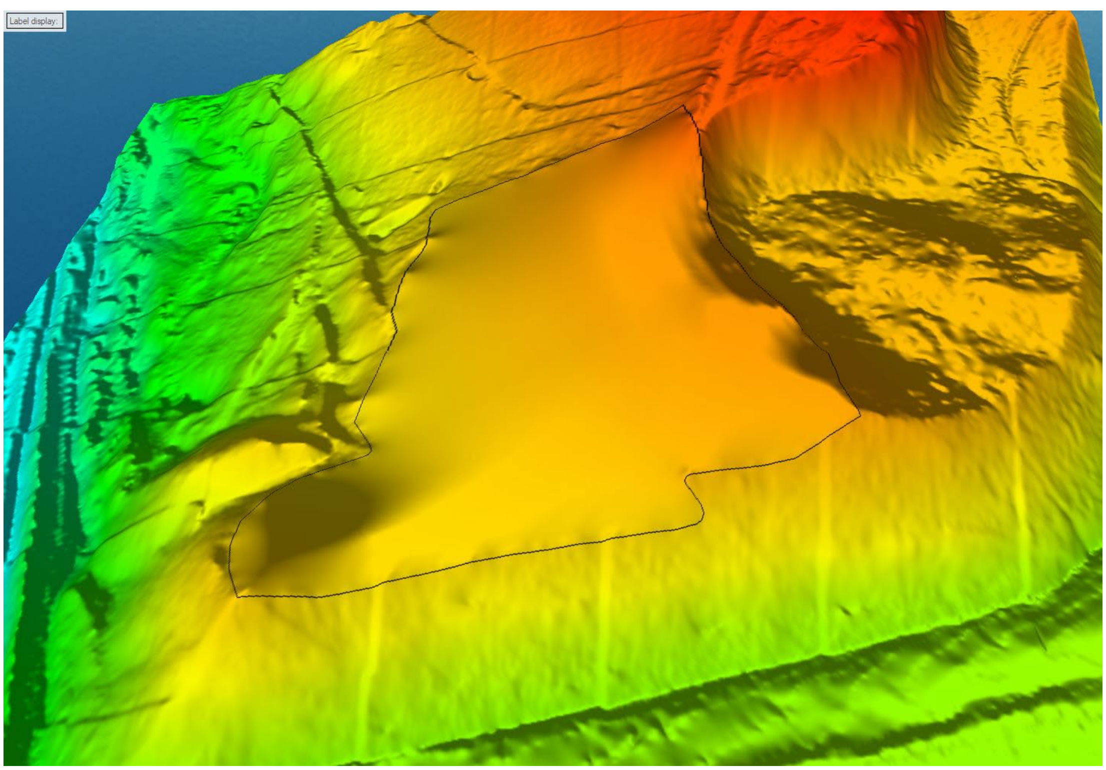
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	244	15616	41280.65625	
2	2	1	64	-41.421875	
3	3	2	128	-9.46875	
4	4	1	64	-7.515625	
5	5	30	1920	-2925.71875	
6	6	2	128	-53.78125	
				38242.75	CF
				1416.398148	CY

Unique ID: CBC_62222319

Current Surface (Northern Pile):



Historical Surface (Northern Pile):



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

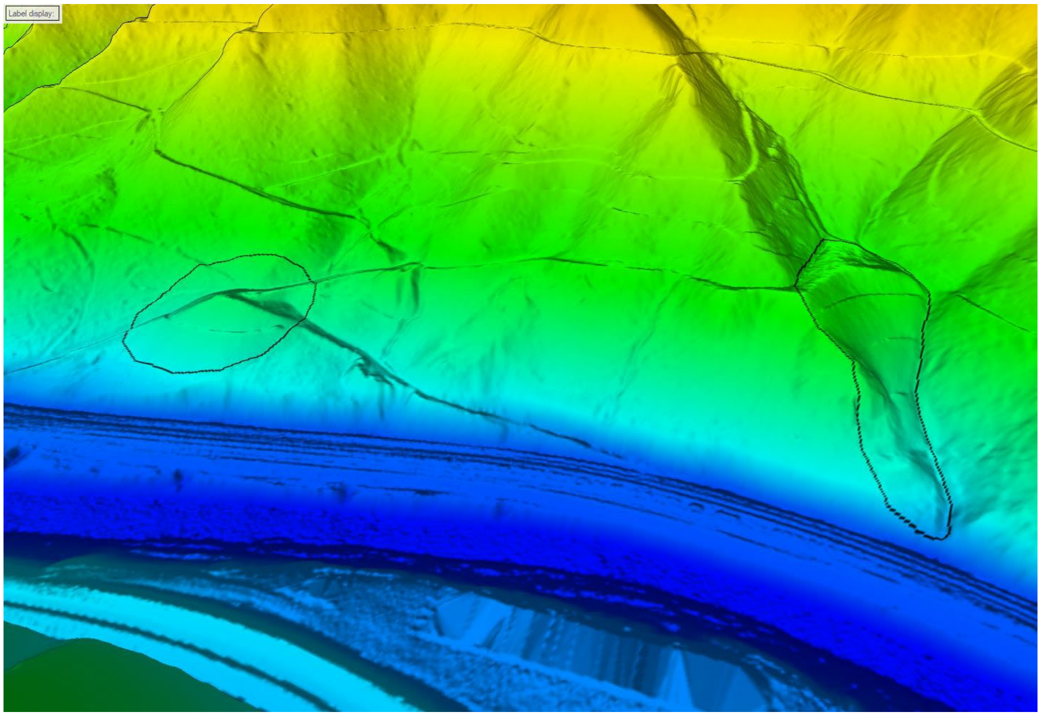
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

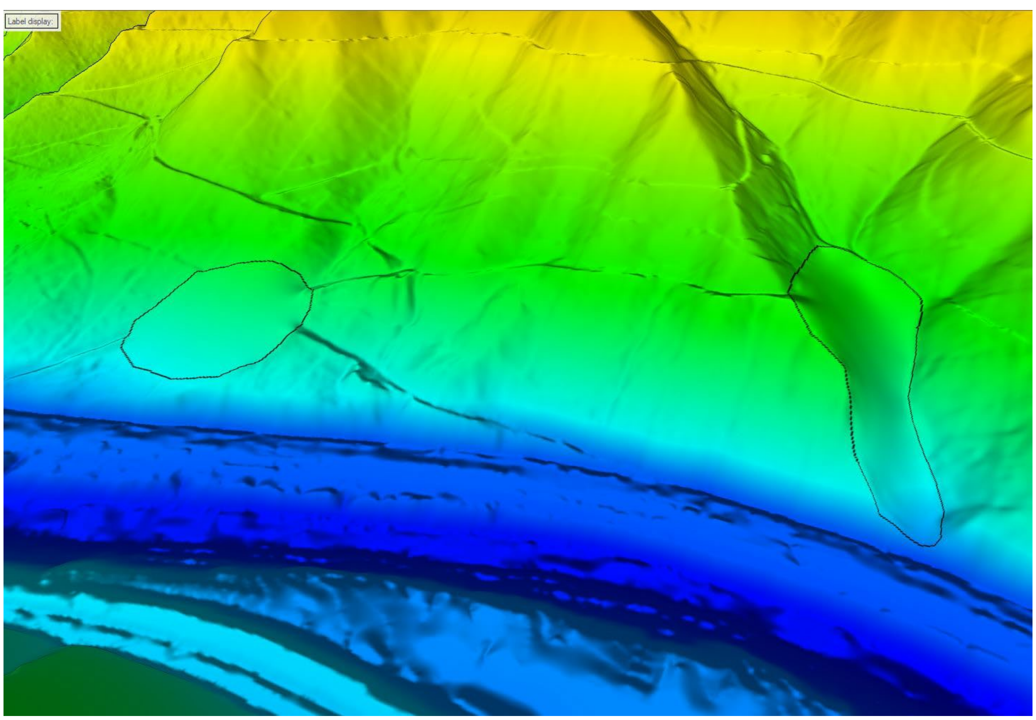
OBJECTID *	Value	Count	AREA	VOLUME
1	1	6	64.583204	18.763187
2	2	8078	86950.52054	1149120.519
3	3	39	419.790827	-148.733732
4	4	1	10.763867	-1.571483
5	5	4	43.055469	-4.183613
6	6	2	21.527735	-0.751579
7	7	10	107.638674	-34.648826
8	8	2	21.527735	-0.402068
9	9	2	21.527735	-7.342345
10	10	129	1388.53889	-841.555205
11	11	22	236.805082	89.655972
12	12	2	21.527735	-37.936325
13	13	3	32.291602	-6.596022
14	14	10	107.638674	31.28249
15	15	1	10.763867	-1.211461
16	16	1	10.763867	-0.628067
17	17	2	21.527735	-2.430805
18	18	4	43.055469	-12.674349
19	19	2	21.527735	-3.510871
20	20	1	10.763867	-7.944134
21	21	1	10.763867	-6.262279
22	22	2	21.527735	-4.485821
23	23	1	10.763867	-2.09969
24	24	22	236.805082	-182.615212
25	25	1	10.763867	-0.851439
26	26	1	10.763867	-3.531894
27	27	1	10.763867	-5.090237
28	28	2	21.527735	-5.400329
29	29	2	21.527735	-3.311151
30	30	1	10.763867	-1.3376
31	31	1	10.763867	-2.525409
32	32	2	21.527735	-2.533293
33	33	1	10.763867	-2.809222
34	34	1	10.763867	-4.654006
35	35	2	21.527735	-10.779635
36	36	1	10.763867	-0.814648
37	37	2	21.527735	-3.489848
38	38	3	32.291602	-18.797349
39	39	2	21.527735	-5.805025
				1147880.905 CF
				42514.10761 CY

Unique ID: CBC_70622602

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

West Pile

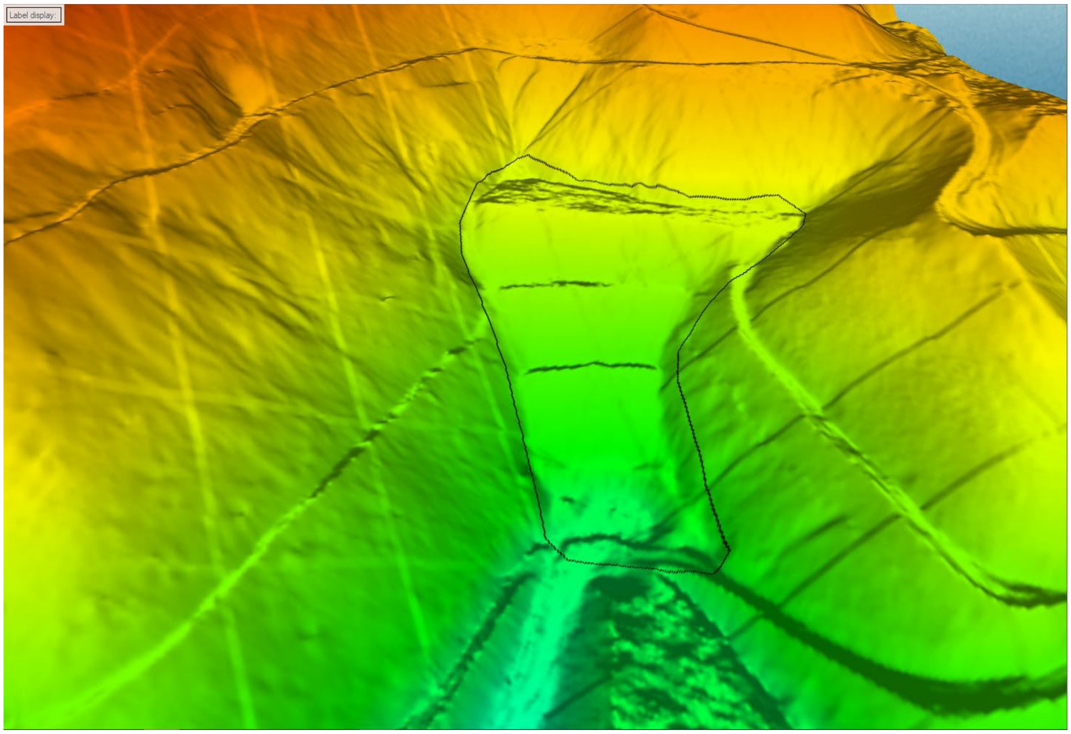
OBJECTID *	Value	Count	AREA	VOLUME
1	1	30	322.916	-391.96665
2	2	7530	81051.92	700773.4854
3	3	1	10.76387	-4.229601
4	4	9	96.87481	-41.419603
5	5	17	182.9857	-141.723816
6	6	25	269.0967	-352.910841
7	7	1	10.76387	-2.25605
8	8	2	21.52774	-13.414102
9	9	4	43.05547	-11.042424
10	10	1	10.76387	-4.723645
11	11	13	139.9303	-79.303371
12	12	400	4305.547	-4104.465498
13	13	52	559.7211	414.75709
14	14	11	118.4025	-39.463134
15	15	1	10.76387	-4.219089
16	16	16	172.2219	-124.838261
17	17	2	21.52774	4.35574
18	18	1	10.76387	-1.804051
19	19	7	75.34707	-78.666106
20	20	72	774.9985	-603.580709
21	21	9	96.87481	-95.772403
22	22	4	43.05547	-20.613226
23	23	2	21.52774	-3.340057
24	24	4	43.05547	-4.583053
25	25	3	32.2916	-5.811595
26	26	2	21.52774	-2.291526
27	27	137	1474.65	-898.199531
28	28	1	10.76387	-0.031535
29	29	4	43.05547	9.159536
30	30	1	10.76387	1.195693
31	31	2	21.52774	2.453142
				694174.7367 Cubic Feet
				25710.17543 Cubic Yards

East Pile

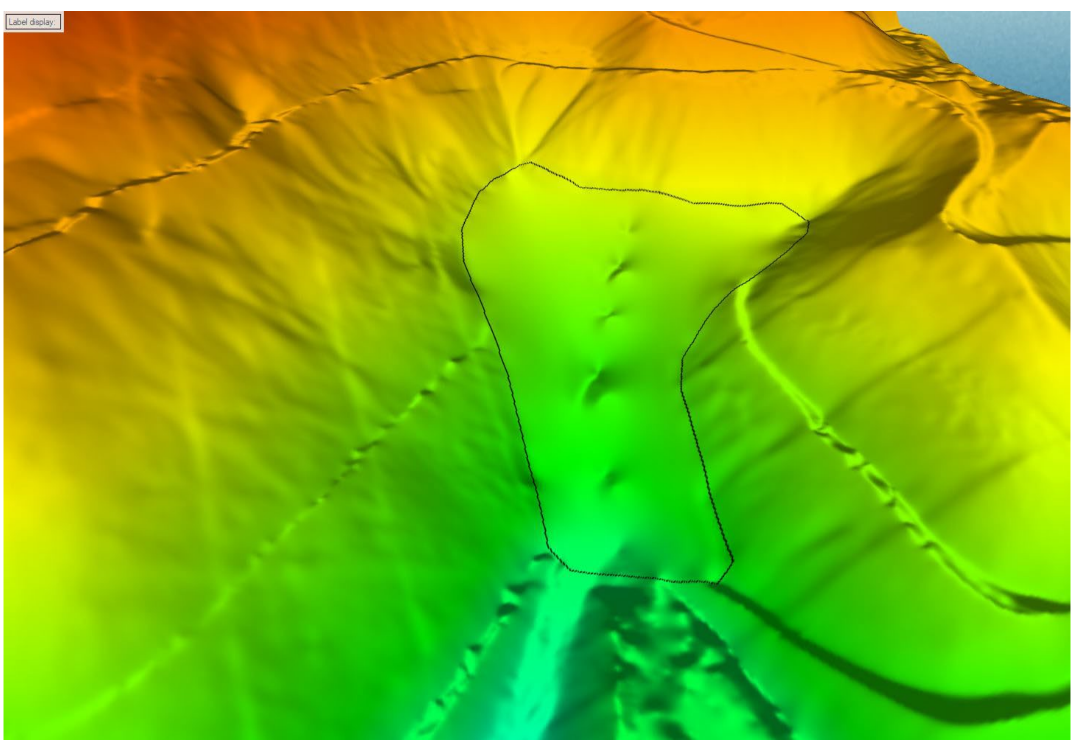
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	4810	51774.2	530891.6437	
2	2	22	236.8051	-47.970951	
3	3	2	21.52774	2.991861	
4	4	2420	26048.56	-114165.1288	
5	5	7	75.34707	33.722492	
6	6	4	43.05547	6.765522	
7	7	22	236.8051	113.079735	
8	8	1	10.76387	0.835671	
9	9	1	10.76387	2.002458	
10	10	1	10.76387	4.184926	
11	11	1	10.76387	6.783917	
12	12	3	32.2916	13.135545	
13	13	7	75.34707	50.451686	
14	14	37	398.2631	346.454097	
15	15	1	10.76387	-3.199465	
16	16	2	21.52774	-2.902513	
17	17	1	10.76387	7.468484	
18	18	151	1625.344	1274.949343	
19	19	4	43.05547	13.904205	
20	20	3	32.2916	13.502136	
21	21	9	96.87481	-12.223664	
22	22	3	32.2916	-2.752722	
23	23	1	10.76387	0.802823	
24	24	219	2357.287	3020.502534	
25	25	1	10.76387	2.011655	
26	26	2	21.52774	1.038019	
27	27	1	10.76387	9.275164	
				421581.3278	Cubic Feet
				15614.12325	Cubic Yards
				41324.29869	Total CY

Unique ID: CBC_70722532

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model

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3: Trim contours inside the gob pile boundary

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

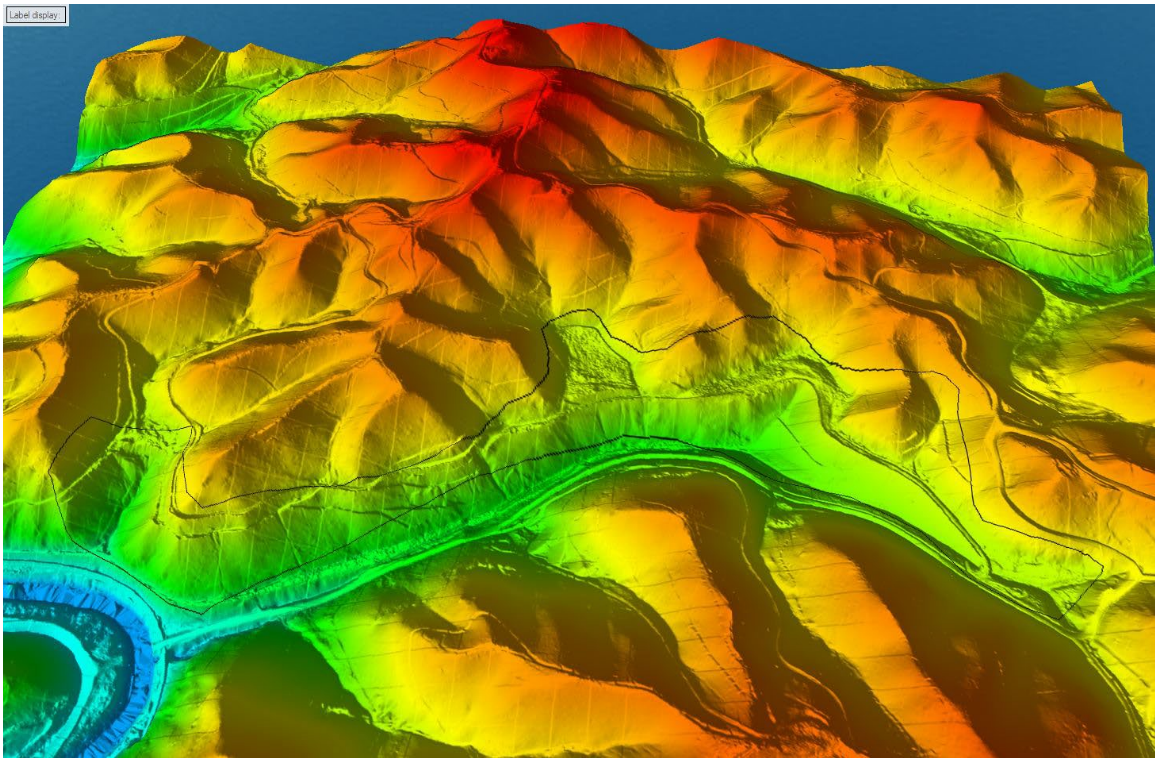
5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

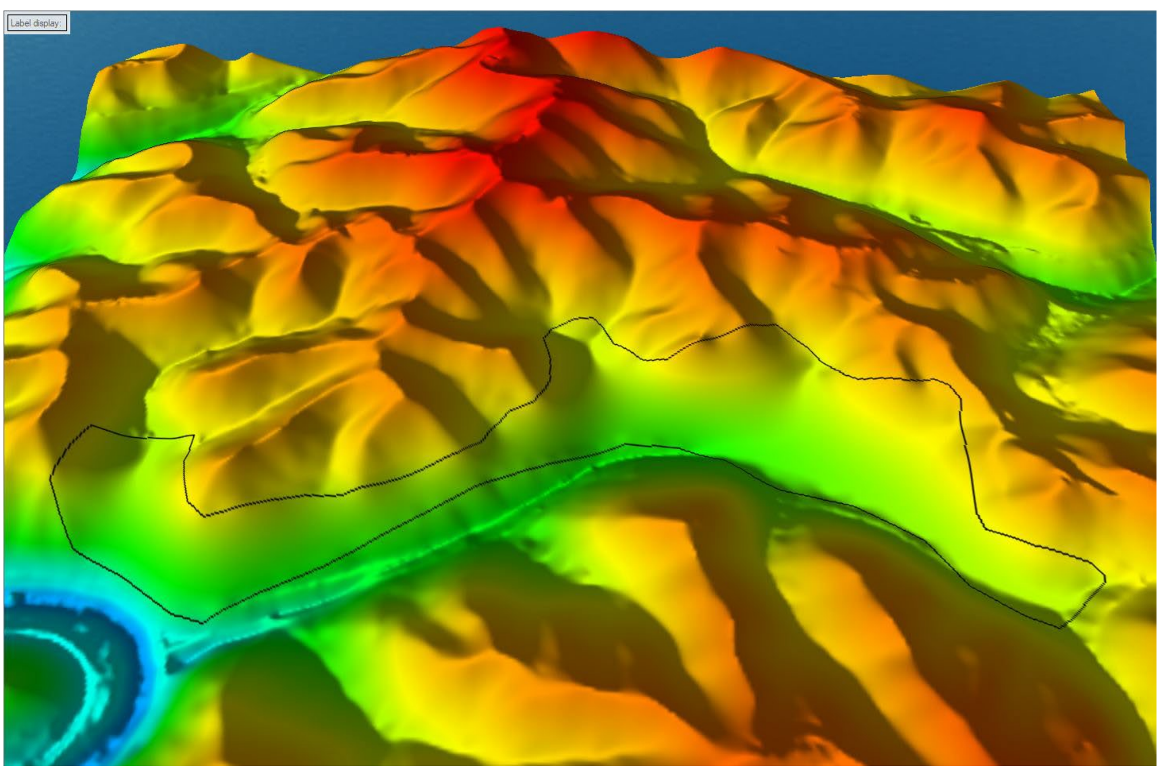
OBJECTID *	Value	Count	AREA	VOLUME
1	1	772	8309.706	-21082.27197
2	2	5	53.81934	13.412788
3	3	1	10.76387	-3.435976
4	4	6110	65767.23	812160.1555
5	5	4	43.05547	-27.345899
6	6	110	1184.025	-869.876054
7	7	1	10.76387	-3.03128
8	8	2768	29794.38	-152107.2055
9	9	1	10.76387	0.829102
10	10	32	344.4438	-166.423422
11	11	1	10.76387	0.073581
12	12	1	10.76387	0.546603
13	13	1	10.76387	1.411181
14	14	1	10.76387	-0.392871
15	15	1	10.76387	-0.51901
16	16	3	32.2916	4.897087
17	17	1	10.76387	0.345568
18	18	102	1097.914	500.254415
19	19	1	10.76387	-0.70559
20	20	1	10.76387	-0.566312
21	21	1	10.76387	-0.540033
22	22	1	10.76387	2.215317
23	23	2	21.52774	3.857753
24	24	11	118.4025	60.797718
				638486.4827 Cubic Feet
				23647.64751 Cubic Yards

Unique ID: CBC_70822204

Current Surface:



Historical Surface:



Process Documentation:

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2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

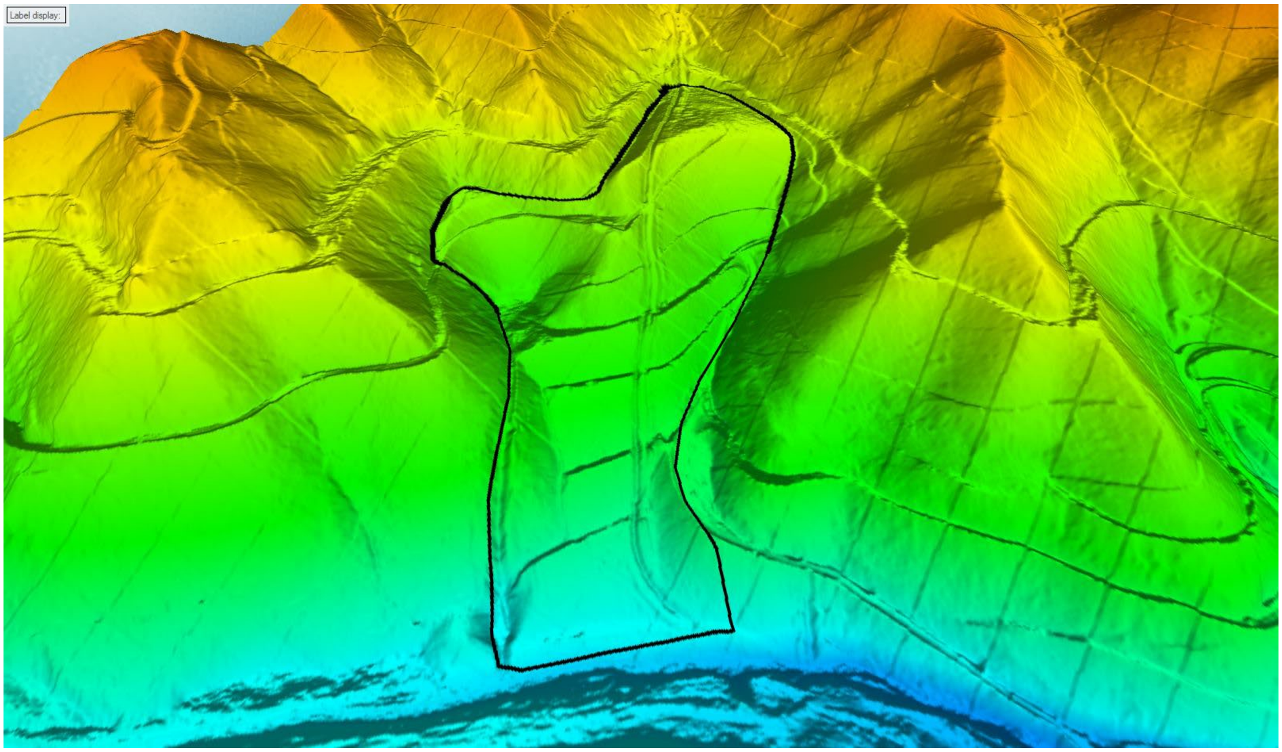
OBJECTID *	Value	Count	AREA	VOLUME
1	1	1325	190800	-1466735.7
2	2	4	576	939.304688
3	3	25	3600	3496.95703
4	4	8603	1238832	27250961.2
5	5	2	288	126.263672
6	6	1	144	-25.769531
7	7	3	432	415.019531
8	8	1	144	6.099609
9	9	1	144	130.324219
10	10	77	11088	27642.3926
11	11	141	20304	-53249.643
12	12	1	144	-31.816406
13	13	1	144	-6.521484
14	14	4	576	433.916016
15	15	4	576	-215.92969
16	16	1328	191232	-3003699.9
17	17	1	144	-52.048828
18	18	2	288	-194.97656
19	19	730	105120	-935609.91
20	20	1	144	105.785156
21	21	5	720	493.119141
22	22	3	432	160.576172
23	23	71	10224	50497.6641
24	24	1011	145584	-1315702.5
25	25	9	1296	1527.69727
26	26	1	144	12.181641
27	27	4	576	545.431641
28	28	206	29664	-128551.39
29	29	1	144	266.361328
30	30	1	144	92.214844
31	31	21	3024	23951.1445
32	32	2	288	-249.36328
33	33	2	288	-276.55664
34	34	1	144	-116.75391
35	35	2	288	-321.25781
36	36	8	1152	-2146.6758
37	37	4	576	-377.50781
38	38	1	144	-5.167969
39	39	1	144	-207.98438
40	40	1	144	-226.8457
41	41	11	1584	-3447.2461
42	42	1	144	-42.679688
43	43	12	1728	-6097.6934
44	44	11	1584	-1855.1074
45	45	1539	221616	-4638976.3
46	46	1	144	-68.361328

OBJECTID *	Value	Count	AREA	VOLUME
47	47	1	144	287.050781
48	48	5	720	691.03125
49	49	54	7776	7786.56445
50	50	1	144	251.683594
51	51	1	144	226.757813
52	52	2	288	195.908203
53	53	163	23472	197383.43

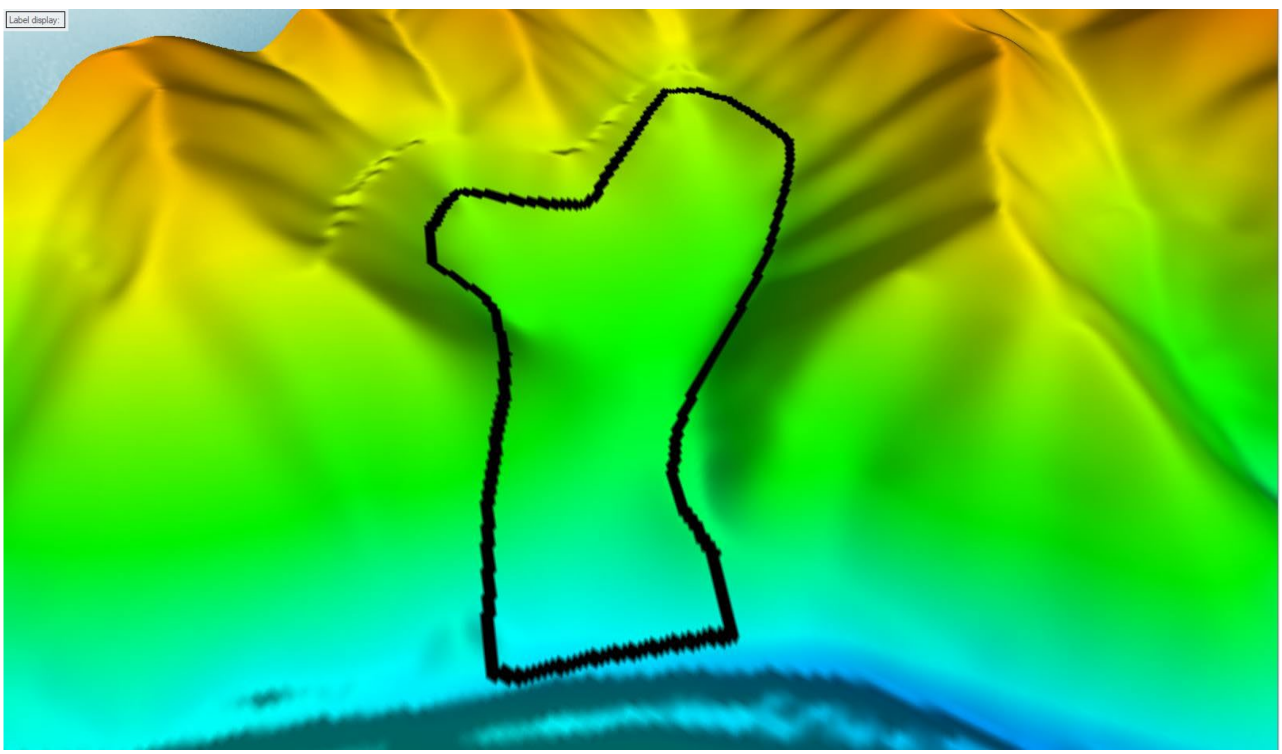
16010134.5	Cubic Feet
592967.943	Cubic Yards

Unique ID: CBC_71422146A

Current Surface:



Historical Surface:



Process Documentation:

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3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

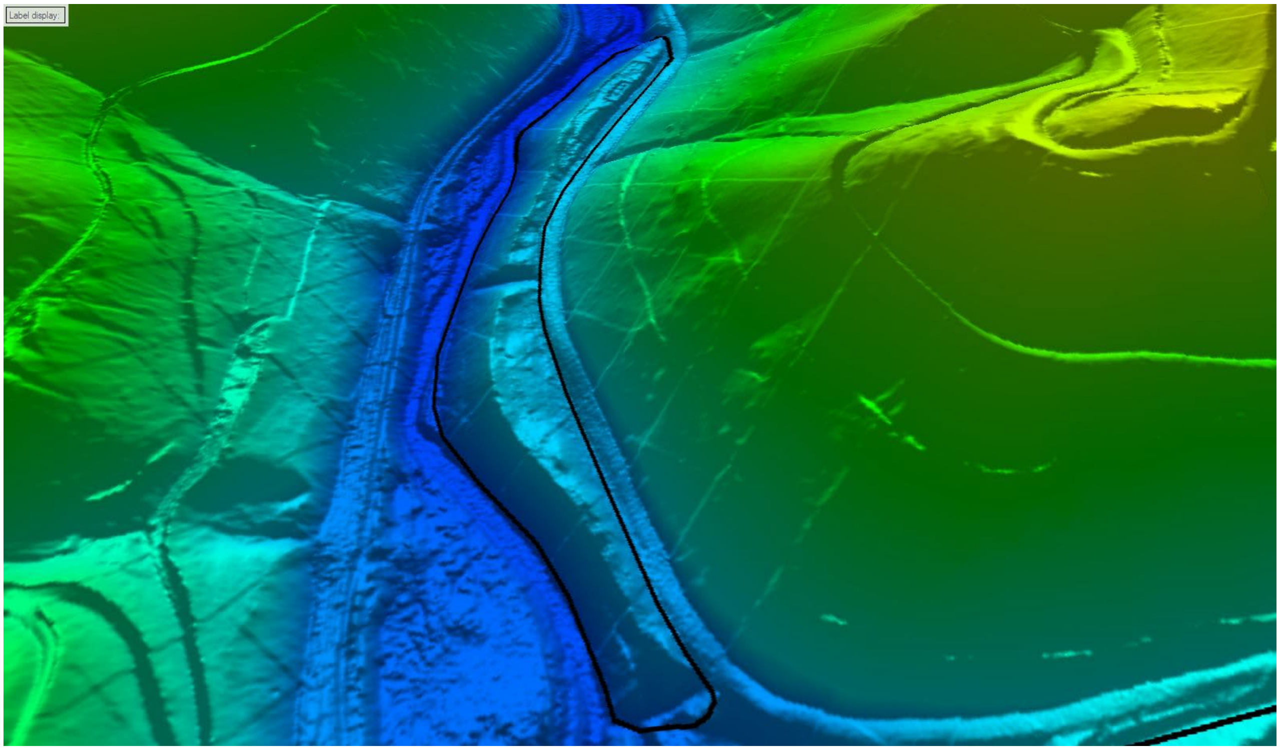
5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

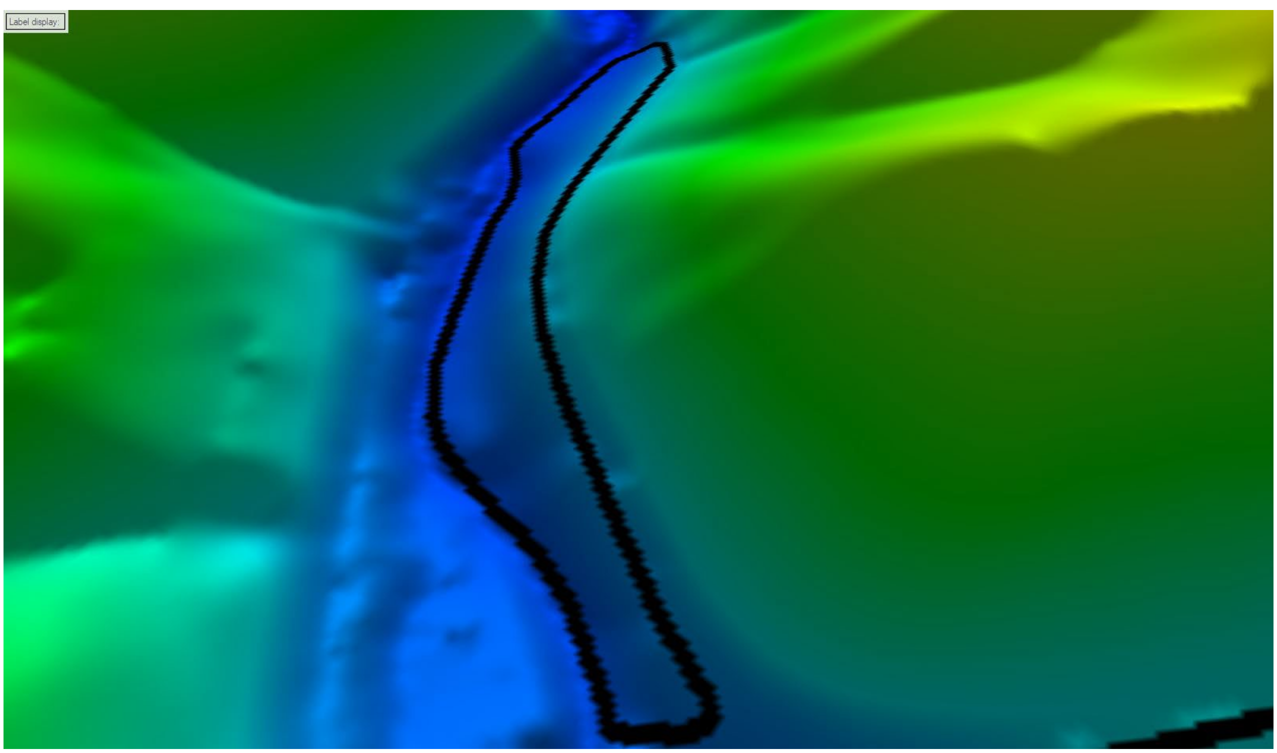
OBJECTID *	VOLUME	
1	6793.53418	
2	13317376.76	
3	-190.760254	
4	-71.849121	
5	-175.63916	
6	-804.217285	
7	-1035.986328	
8	-751.173828	
9	-305040.2407	
10	-10546.05371	
11	-139796.4497	
12	-52368.89356	
13	-47638.14453	
14	-385.061523	
15	-14232.44238	
	12751133.38	CF
	472264.1994	CY

Unique ID: CBC_71422146B

Current Surface:



Historical Surface:



Process Documentation:

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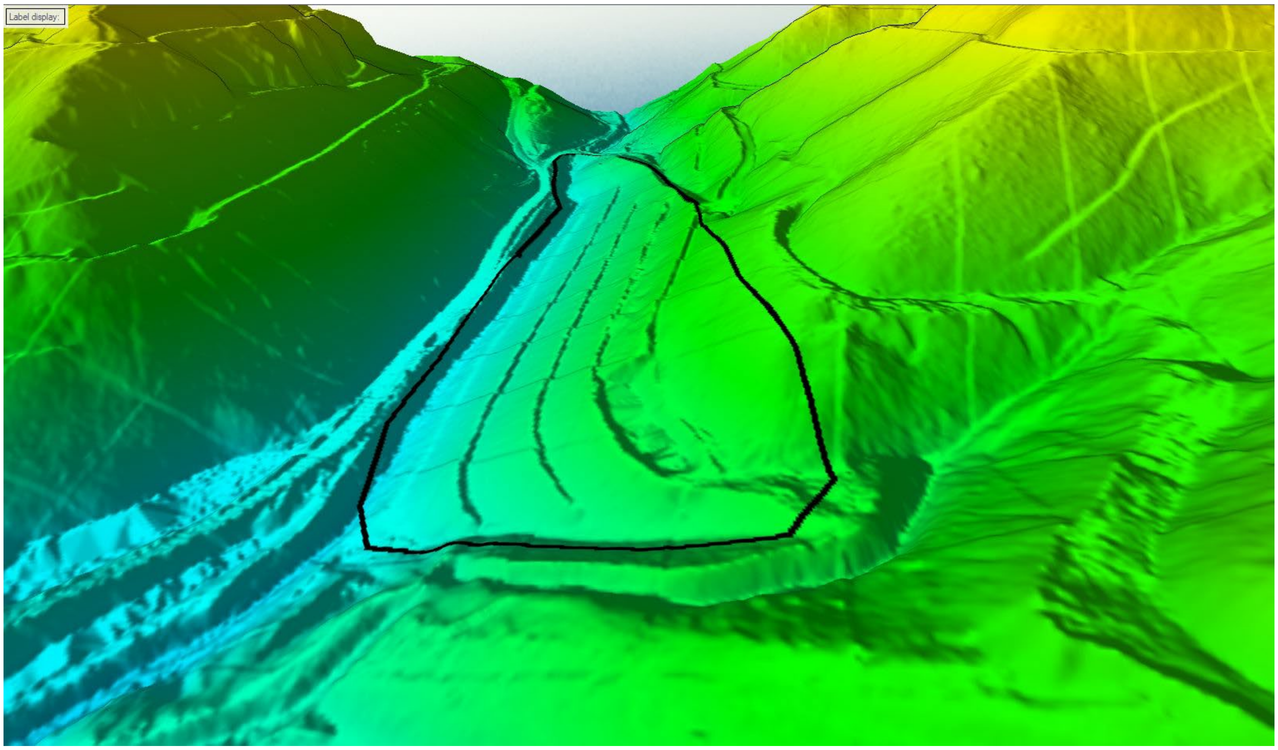
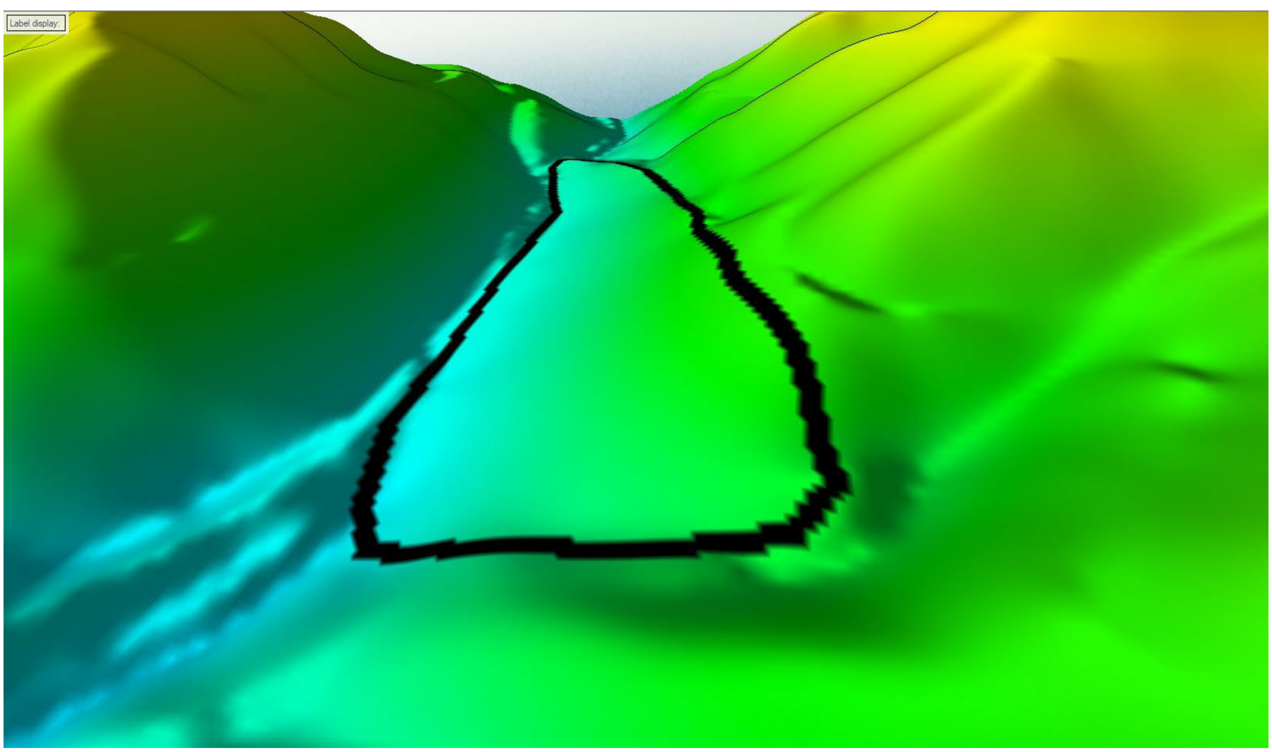
OBJECTID *	VOLUME	
1	-2266.202148	
2	-35.21875	
3	-2626.428711	
4	-86.37207	
5	2870406.913	
6	-61.919922	
7	-584.698242	
8	-53.378418	
9	-54.766113	
10	-412.265137	
11	-47.540527	
12	-61.369629	
13	-556.705078	
14	-950.930176	
15	-904.442383	
16	-1134.751953	
17	-58.953125	
18	-5551.259766	
19	211.671387	
20	-95.416016	
21	-15.719238	
22	-303.785645	
	2854756.461	CF
	105731.7208	CY

Unique ID: CBC_71422146C

Current Surface:



Historical Surface:



Process Documentation:

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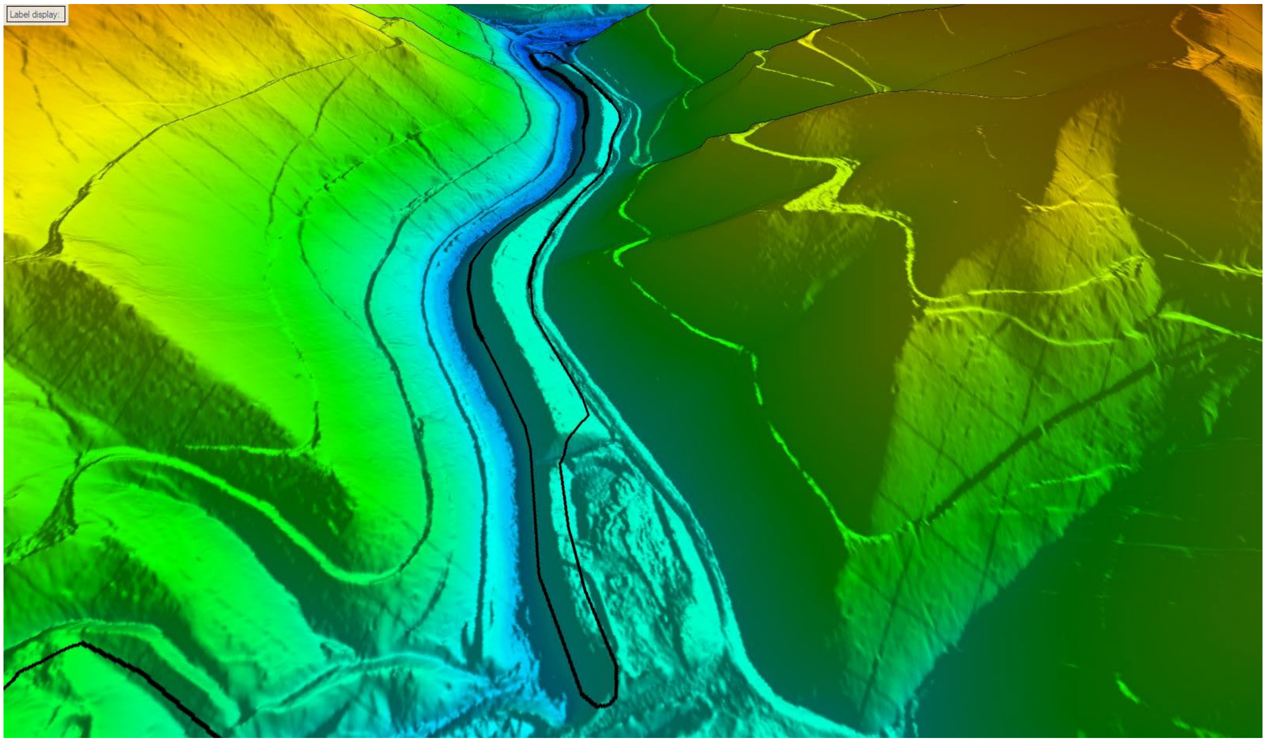
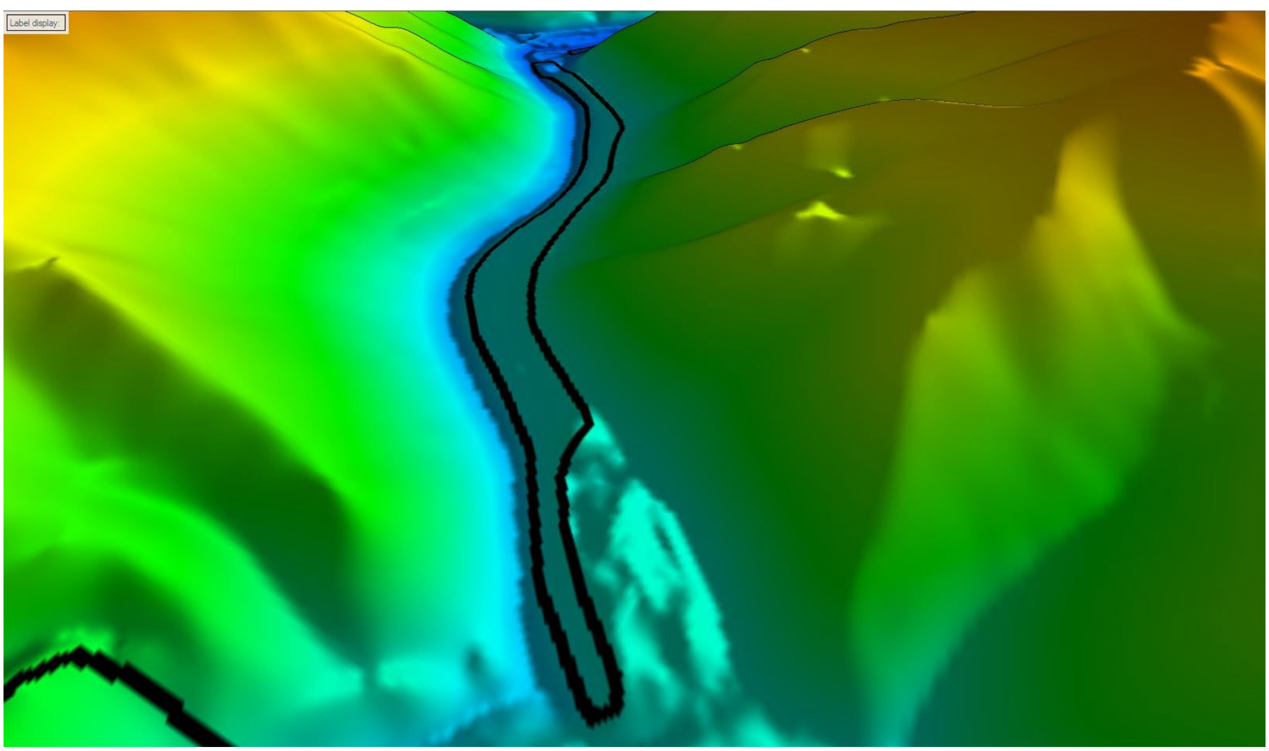
OBJECTID *	VOLUME	
1	-958549.7954	
2	0.023926	
3	151.234863	
4	25.217773	
5	34.070313	
6	-751.269531	
7	-202.101074	
8	53.115234	
9	-3.397461	
10	1765930.404	
11	-1449.112793	
12	-888.436035	
13	-7914.624512	
14	-19065.59375	
15	-107.618164	
16	-5.861816	
17	134.678223	
18	-13608.67334	
19	-5.790039	
20	-190.78418	
21	-112660.0679	
22	-6074.92334	
23	-226.936035	
24	19235.94531	
25	-198.823242	
	663660.8809	CF
	24580.03262	CY

Unique ID: CBC_71422146D

Current Surface:



Historical Surface:



Process Documentation:

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2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

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4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

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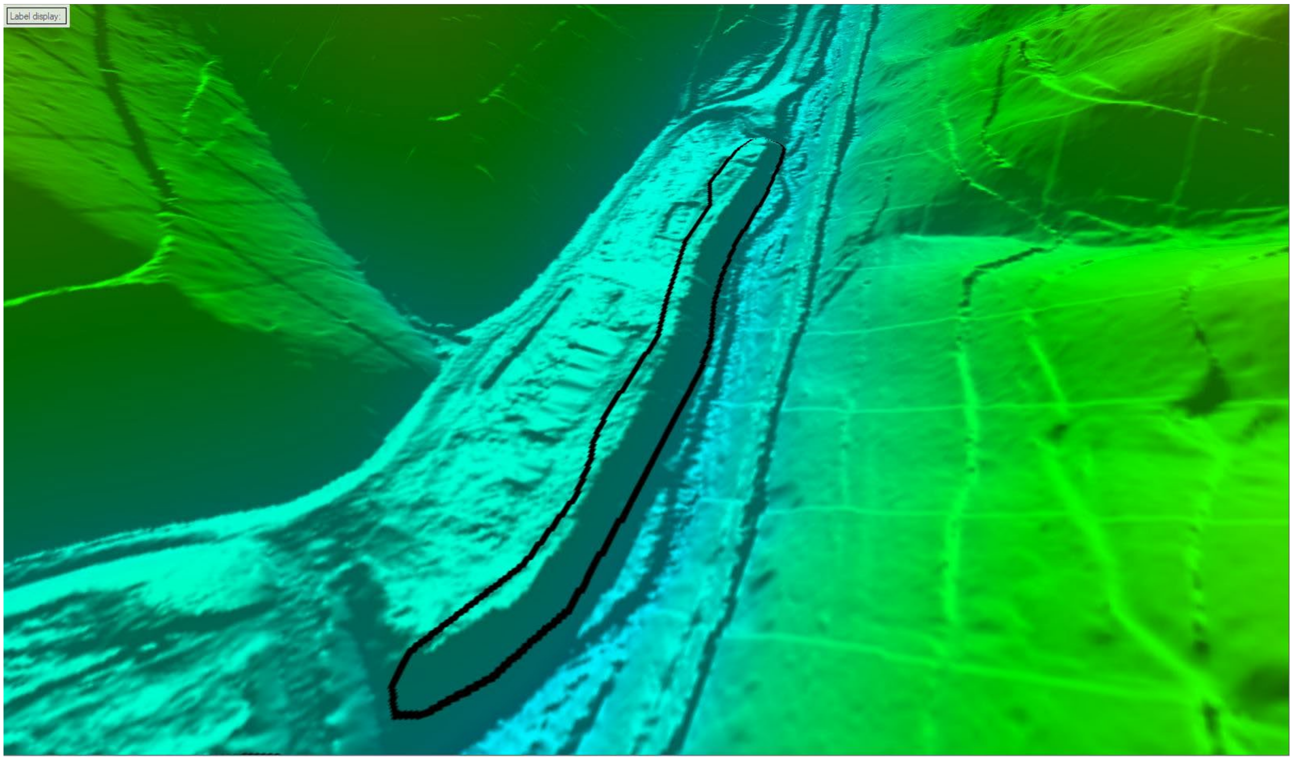
OBJECTID *	VOLUME
1	-59440.7085
2	32085.31006
3	4.617676
4	2485912.382
5	-78.045898
6	-26.007324
7	-16.484863
8	-6420.220215
9	-650.32666
10	-351.326172
11	-185.520508
12	-178.70166
13	-63.905762
14	-17.489746
15	-193.487793
16	-49.861328
17	-8130.865723
18	-1676.981934
19	-250.837891
20	-504.570801
21	-954.854004
22	-2.177246
23	-4891.530273
24	-227.031738
25	-1002.777344
26	-148.794434
27	-52.804199
28	-239.449219
29	-76.969238
30	-90.032715
31	-95.416016
32	-23.351563
33	-258.135254
34	-101.325684
35	-147.90918
36	-14330.13135
37	-438.583496
38	-49.119629
39	-499.689941
40	-758.949707
41	-233.707031
42	-156.067871
43	-307.15918
44	-37011.1499
45	-42.157227
46	121609.6978

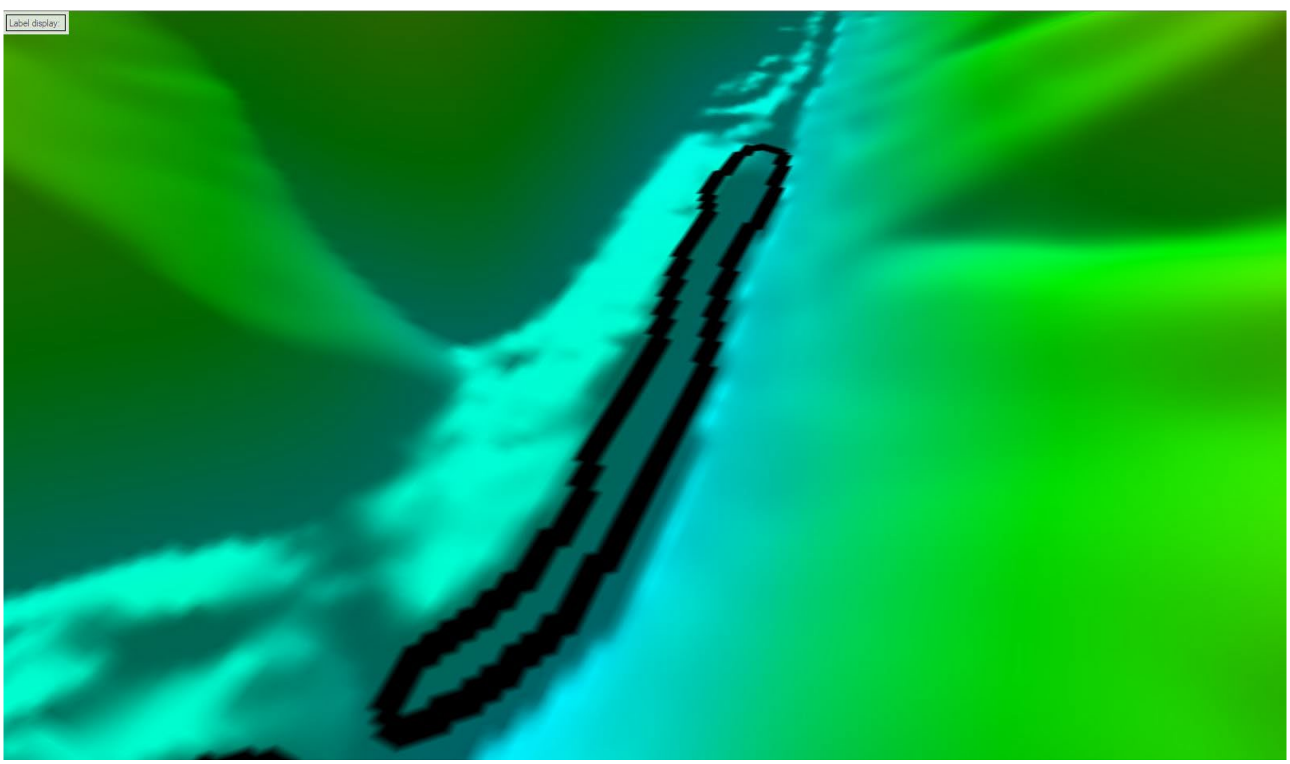
OBJECTID *	VOLUME	
47	-315.365723	
48	-5371.888184	
49	-13313.04639	
50	32.419434	
51	-1700.931641	
	2478568.579	CF
	91798.83626	CY

Unique ID: CBC_71422146E

Current Surface:



Historical Surface:



Process Documentation:

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3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

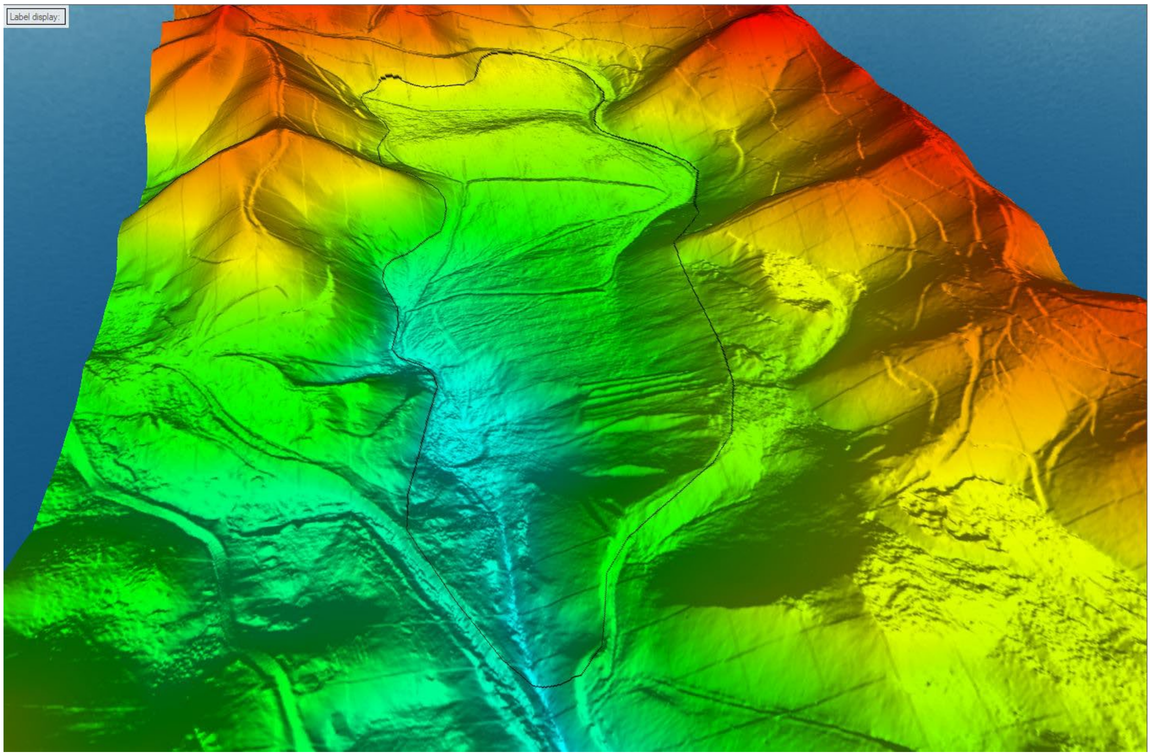
5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

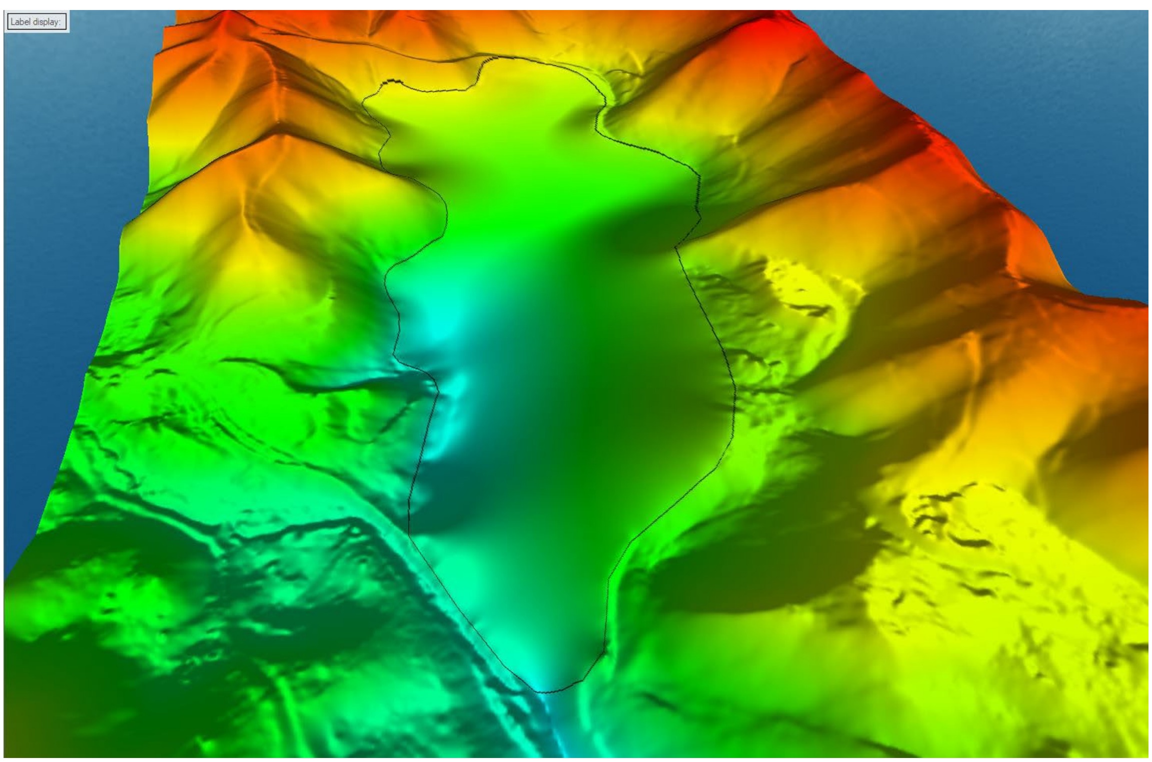
OBJECTID *	VOLUME	
1	278853.9756	
2	-635.851563	
3	-3.756348	
4	-7377.490723	
	270836.877	CF
	10030.99544	CY

Unique ID: CBC_72122629

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

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OBJECTID *	Value	Count	AREA	VOLUME
1	1	57698	1442450	24707424.71
2	2	1	25	-0.811768
3	3	3004	75100	-198600.7385
4	4	1	25	-2.502441
5	5	1	25	-0.537109
6	6	1	25	-0.372314
7	7	3	75	-38.964844
8	8	29793	744825	-8333155.353
9	9	2	50	-6.530762
10	10	5	125	42.358398
11	11	1	25	1.11084
12	12	25	625	-123.66333
13	13	6	150	-20.251465
14	14	2	50	13.238525
15	15	3	75	-4.205322
16	16	4	100	-21.600342
17	17	3	75	-28.985596
18	18	2	50	-11.474609
19	19	1	25	5.0354
20	20	6	150	-32.904053
21	21	5	125	7.940674
22	22	1	25	-7.720947
23	23	1	25	-0.390625
24	24	1	25	-5.047607
25	25	1	25	-2.111816
26	26	3	75	-13.842773
27	27	5	125	-27.929688
28	28	1	25	-2.935791
29	29	1	25	-18.572998
30	30	1	25	-1.165771
31	31	1	25	3.961182
32	32	159	3975	-2744.87915
33	33	2	50	-17.993164
34	34	1	25	-7.299805
35	35	4	100	-42.840576
36	36	1	25	-0.958252
37	37	2	50	2.789307
38	38	14	350	133.416748
39	39	2	50	-12.255859
40	40	11	275	-60.321045
41	41	119	2975	3701.660156
42	42	1	25	3.137207
43	43	3	75	-23.309326
44	44	1	25	-1.68457
45	45	10	250	45.391846
46	46	1	25	-2.111816

OBJECTID *	Value	Count	AREA	VOLUME
47	47	1	25	10.662842
48	48	1	25	4.052734
49	49	1	25	0.689697
50	50	1	25	-2.130127
51	51	1	25	-4.833984
52	52	1410	35250	-64901.47095
53	53	1	25	-1.324463
54	54	2	50	24.633789
55	55	1	25	0.854492
56	56	3	75	41.52832
57	57	10	250	49.816895
58	58	4	100	42.230225
59	59	1	25	1.940918
60	60	3	75	32.946777
61	61	1	25	-0.976563
62	62	1	25	4.949951
63	63	1	25	3.204346
64	64	160	4000	1516.253662
65	65	2	50	-3.411865
66	66	1	25	-0.45166
67	67	1	25	9.069824
68	68	1	25	1.89209
69	69	1	25	-6.378174
70	70	1	25	-1.513672
71	71	1	25	9.423828
72	72	1	25	-2.563477
73	73	1	25	0.018311
74	74	4	100	31.915283
75	75	1	25	-8.435059
76	76	1	25	-0.872803
77	77	1	25	-2.667236
78	78	28	700	276.055908
79	79	1	25	1.013184
80	80	1	25	0.250244
81	81	1	25	-2.685547
82	82	2	50	2.423096
83	83	1	25	6.738281
84	84	4	100	12.261963
85	85	1	25	1.904297
86	86	113	2825	3474.11499
87	87	4	100	20.410156
88	88	1	25	3.125
89	89	1	25	10.888672
90	90	1	25	0.787354
91	91	1	25	-0.415039
92	92	1	25	-7.623291

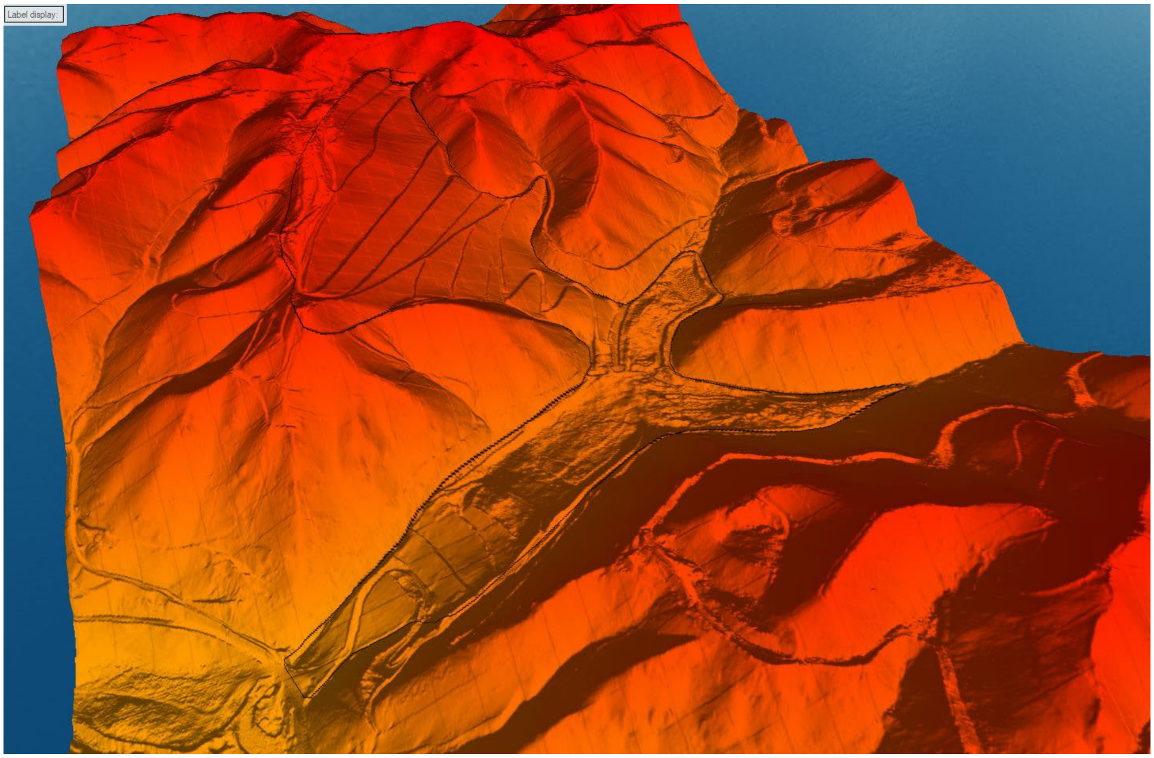
OBJECTID *	Value	Count	AREA	VOLUME
93	93	3	75	8.502197
94	94	938	23450	32074.11499
95	95	1	25	0.952148
96	96	1	25	-1.159668
97	97	1	25	-3.686523
98	98	1	25	-2.148438
99	99	1	25	-1.263428
100	100	1	25	-2.703857
101	101	1	25	-3.863525
102	102	3	75	-9.490967
103	103	1	25	-5.834961
104	104	1	25	-0.891113
105	105	6	150	-22.857666
106	106	7	175	-21.972656
107	107	11	275	-92.340088
108	108	1	25	-9.503174
109	109	1	25	-1.751709
110	110	1	25	2.716064
111	111	9	225	-63.006592
112	112	1	25	1.538086
113	113	2	50	-6.02417
114	114	1	25	1.446533
115	115	3	75	-15.19165
116	116	2	50	21.276855
117	117	262	6550	4625.189209
118	118	1	25	-4.23584
119	119	2	50	-16.955566
120	120	2	50	12.689209
121	121	1	25	3.460693
122	122	1	25	2.410889
123	123	3	75	14.666748
124	124	1	25	1.800537
125	125	1	25	1.501465
126	126	2	50	26.812744
127	127	1	25	4.101563
128	128	11	275	45.697021
129	129	49	1225	481.506348
130	130	2	50	-14.532471
131	131	1	25	0.732422
132	132	1	25	-4.095459
133	133	3	75	2.337646
134	134	13	325	-109.143066
135	135	1	25	1.269531
136	136	1	25	0.061035
137	137	1	25	0
138	138	4	100	7.843018

OBJECTID *	Value	Count	AREA	VOLUME
139	139	1	25	-0.280762
140	140	33	825	-118.347168
141	141	1	25	-1.989746
142	142	781	19525	-54889.60571
143	143	5	125	23.596191
144	144	21	525	233.80127
145	145	44	1100	549.963379
146	146	17	425	80.163574
147	147	1	25	3.192139
148	148	1	25	2.166748
149	149	88	2200	571.002197
150	150	1	25	-1.953125
151	151	1	25	0.518799
152	152	1	25	5.865479
153	153	5	125	19.006348
154	154	8	200	38.226318
155	155	2	50	9.606934
156	156	28	700	298.529053
157	157	3	75	-6.37207
158	158	1	25	-0.012207
159	159	2	50	13.220215
160	160	1	25	0.323486
161	161	1	25	0.543213
162	162	1	25	2.947998
163	163	2	50	9.997559
164	164	114	2850	-1977.703857
165	165	1	25	9.057617
166	166	1	25	1.727295
167	167	3	75	12.432861
168	168	1	25	13.476563
169	169	3	75	26.019287
170	170	1	25	13.330078
171	171	1	25	-1.275635
172	172	1	25	-4.309082
173	173	4	100	29.858398
174	174	1	25	-3.521729
175	175	4	100	26.306152
176	176	1	25	4.077148
177	177	1	25	1.818848
178	178	8	200	32.037354
179	179	1	25	3.704834
180	180	1	25	-3.625488
181	181	1	25	-0.946045
182	182	90	2250	-978.399658
183	183	1	25	-0.836182
184	184	3	75	13.519287

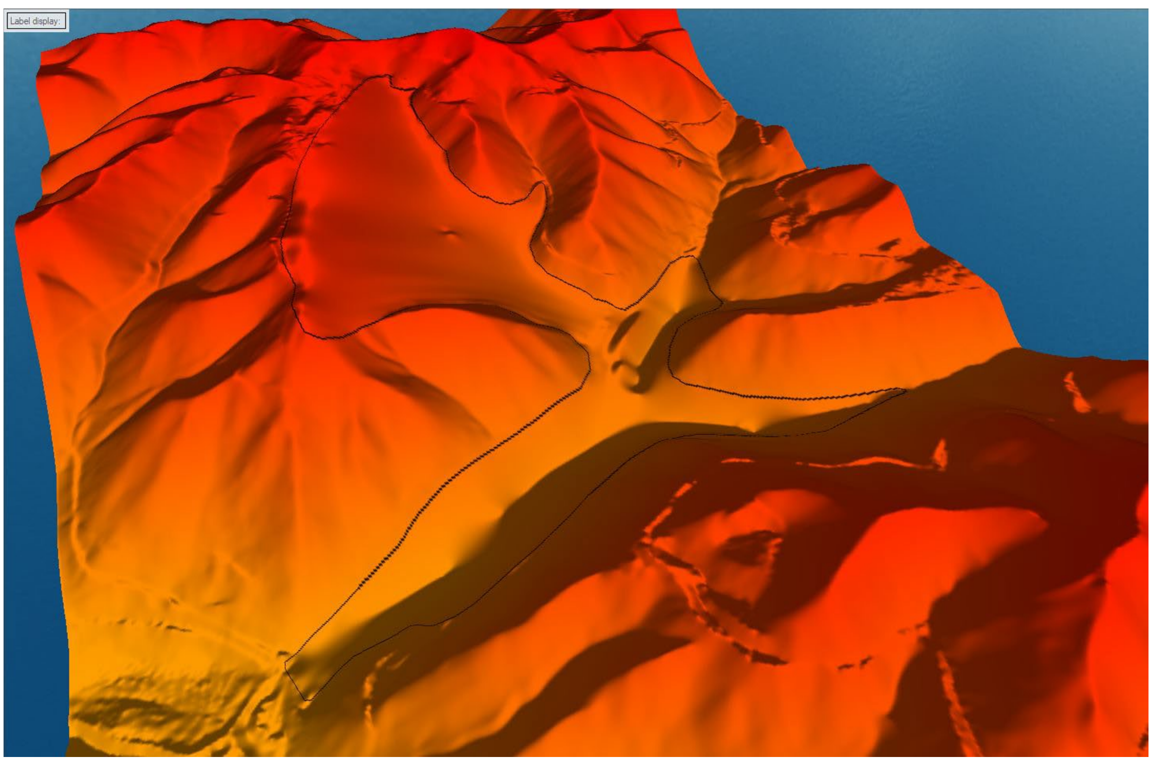
OBJECTID *	Value	Count	AREA	VOLUME
185	185	1	25	1.690674
186	186	1	25	8.984375
187	187	1	25	3.100586
188	188	3	75	10.461426
189	189	1	25	1.507568
190	190	2	50	8.306885
191	191	3	75	7.23877
192	192	1	25	5.004883
193	193	1	25	3.741455
194	194	36	900	-416.912842
195	195	15	375	-98.498535
196	196	1	25	10.839844
197	197	1	25	-0.170898
198	198	11	275	-75.061035
199	199	2	50	-2.044678
				16097449.81 CF
				596201.8448 CY

Unique ID: CBC_72122659

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	56702	2778398	81132881.01
2	2	4	196	-101.750366
3	3	12	588	-445.982544
4	4	1	49	-6.573608
5	5	7	343	-388.805908
6	6	1	49	-19.846436
7	7	3	147	-151.617676
8	8	27	1323	-1976.807861
9	9	3	147	-84.541748
10	10	3	147	-39.824463
11	11	28	1372	-2648.470337
12	12	1	49	-3.259888
13	13	1	49	-2.685669
14	14	15	735	-926.866821
15	15	1	49	-5.562744
16	16	1	49	-11.532227
17	17	6	294	-148.746582
18	18	1	49	-24.876831
19	19	2	98	-52.002686
20	20	1	49	-34.297607
21	21	1	49	-47.283325
22	22	1	49	-40.093628
23	23	1	49	-33.005615
24	24	1	49	-23.447266
25	25	4	196	-242.5177
26	26	214	10486	-41293.54773
27	27	2	98	-157.024902
28	28	551	26999	-102911.2451
29	29	2	98	50.69873
30	30	25	1225	-5518.630981
31	31	11	539	621.831055
32	32	2	98	-73.177002
33	33	52	2548	-6786.577759
34	34	1	49	12.596924
35	35	80	3920	-10514.86646
36	36	1	49	-3.074463
37	37	3	147	-480.166504
38	38	14	686	-550.095581
39	39	2	98	-188.116455
40	40	2	98	85.839722
41	41	1	49	-16.191772
42	42	14	686	-2255.07666
43	43	4	196	-272.47876
44	44	1	49	-43.652588
45	45	34	1666	-4460.315918
46	46	84	4116	-13532.24841

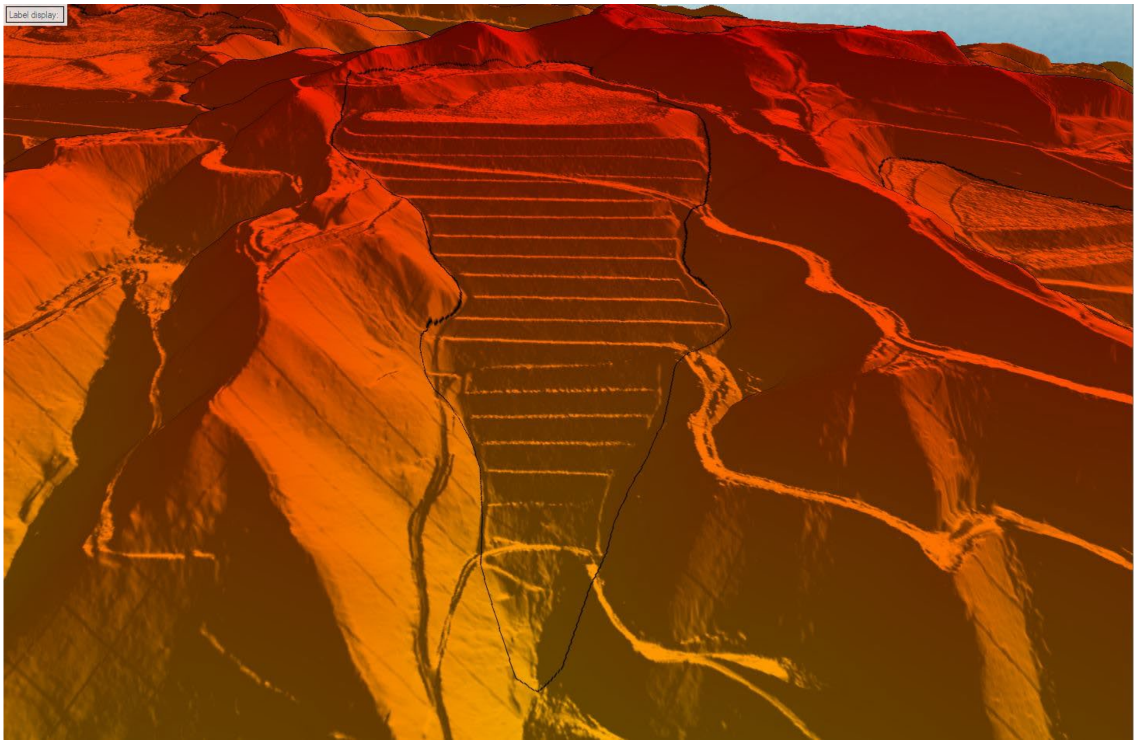
OBJECTID *	Value	Count	AREA	VOLUME
47	47	51	2499	-6191.035156
48	48	11	539	-1853.590088
49	49	1	49	-35.709229
50	50	1214	59486	-185301.5391
51	51	1	49	-12.519165
52	52	1	49	-22.143311
53	53	42	2058	-4276.171143
54	54	1	49	9.64209
55	55	59	2891	-8887.650146
56	56	14	686	653.257568
57	57	39	1911	-1553.734253
58	58	8	392	583.501953
59	59	1	49	13.374512
60	60	13	637	-488.073975
61	61	3	147	-156.408813
62	62	1	49	-25.684326
63	63	1	49	-20.247192
64	64	39	1911	-2446.135986
65	65	1	49	7.608398
66	66	4	196	118.127563
67	67	5	245	-53.844971
68	68	3	147	-181.082275
69	69	2	98	34.285645
70	70	1	49	-1.393677
71	71	161	7889	-20646.23853
72	72	1	49	-1.878174
73	73	12	588	-214.937256
74	74	1	49	-5.67041
75	75	2	98	-14.654541
76	76	3	147	-35.422119
77	77	4	196	265.851318
78	78	1	49	-7.716064
79	79	5	245	-27.706055
80	80	1	49	-0.980957
81	81	3822	187278	-1525498.039
82	82	1	49	22.43042
83	83	3	147	-33.843018
84	84	3	147	-28.112793
85	85	1	49	-9.10376
86	86	1	49	-49.645996
87	87	1	49	-1.949951
88	88	1	49	3.624756
89	89	1	49	-34.620605
90	90	3	147	195.00708
91	91	2	98	45.393188
92	92	27	1323	-411.487549

OBJECTID *	Value	Count	AREA	VOLUME
93	93	1	49	4.940674
94	94	2	98	-3.206055
95	95	1	49	-7.560547
96	96	1	49	-32.144287
97	97	278	13622	-35679.48877
98	98	1	49	-2.727539
99	99	20	980	-272.083984
100	100	1	49	-52.289795
101	101	62	3038	-13099.44299
102	102	15	735	-84.577637
103	103	4	196	-37.730957
104	104	1	49	-4.833008
105	105	1	49	-64.456055
106	106	6	294	-193.691162
107	107	54	2646	-4975.120972
108	108	1	49	-8.421875
109	109	1	49	-13.817139
110	110	1	49	-33.639648
111	111	1	49	5.538818
112	112	1	49	-9.797607
113	113	5	245	-132.823975
114	114	3	147	-94.841797
115	115	1	49	-8.912354
116	116	3	147	-137.573242
117	117	2	98	-14.582764
118	118	1	49	-11.735596
119	119	1	49	-25.708252
120	120	2	98	6.74707
121	121	3	147	-25.181885
122	122	1	49	35.75708
123	123	12	588	-605.46582
124	124	1	49	-11.747559
125	125	13	637	-1433.818237
126	126	6	294	-100.954834
127	127	16	784	-130.622803
128	128	1	49	18.231445
129	129	19	931	1259.369385
130	130	1	49	7.931396
131	131	27	1323	812.794678
132	132	4	196	-171.95459
133	133	3	147	18.363037
134	134	2	98	18.91333
135	135	1	49	-81.640747
136	136	2	98	-72.584839
137	137	2	98	-92.634644
138	138	1	49	-128.613037

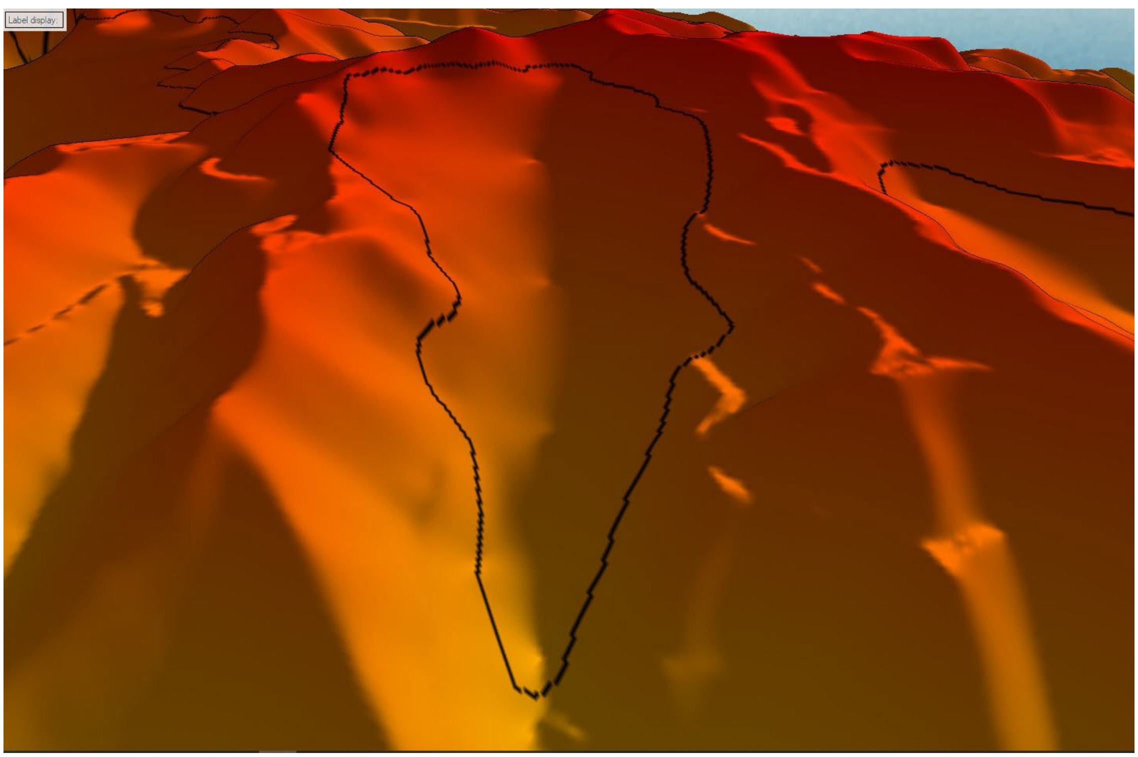
OBJECTID *	Value	Count	AREA	VOLUME
139	139	183	8967	-42165.46301
140	140	28	1372	-3180.57373
141	141	1	49	-30.882202
142	142	1	49	-40.021851
143	143	14	686	-327.85498
144	144	1	49	-23.303711
145	145	1	49	-8.11084
				79079114.18 CF
				2928856.081 CY

Unique ID: CBC_72122745

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

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3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

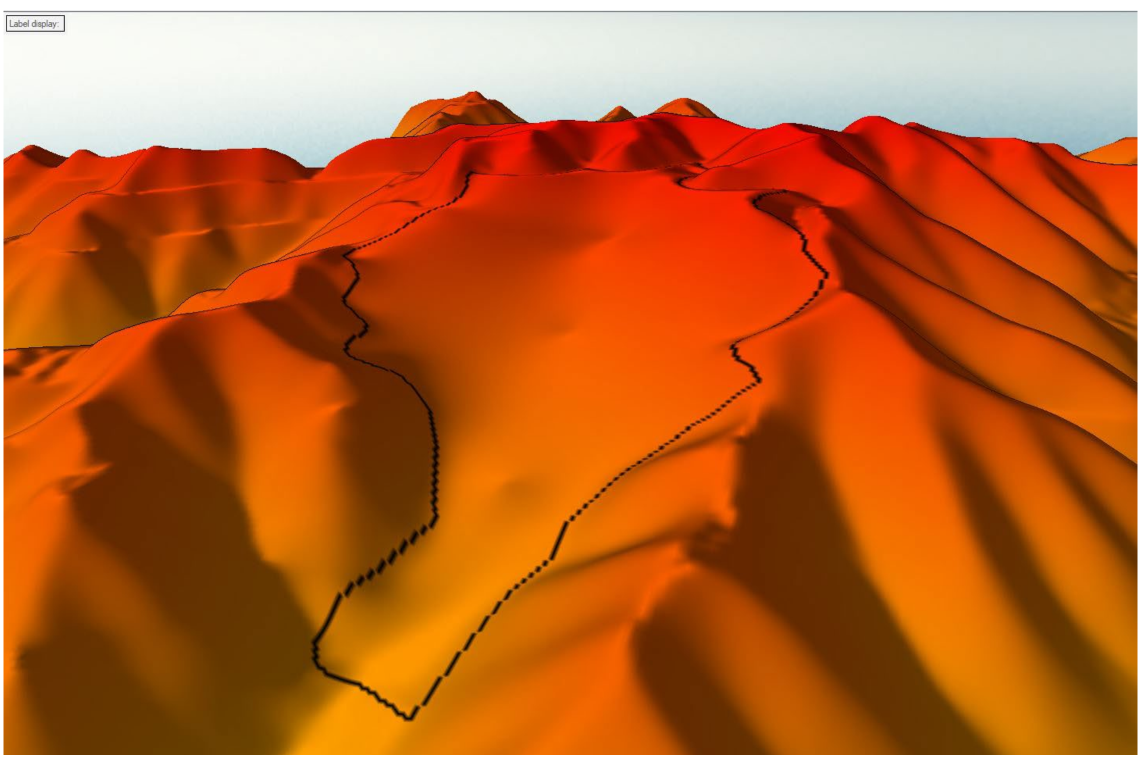
OBJECTID *	Value	Count	AREA	VOLUME
1	1	362	104618	-1163757.632
2	2	4	1156	2996.681641
3	3	2	578	342.164429
4	4	2	578	278.063721
5	5	6583	1902487	101960372.8
6	6	41	11849	-107769.0243
7	7	3	867	-3246.099365
8	8	1	289	-1.940308
9	9	5	1445	-4466.799805
10	10	2	578	-2663.79541
11	11	2	578	-1821.172729
12	12	48	13872	-142177.4165
13	13	3	867	-1225.921631
14	14	1	289	-138.255737
15	15	2	578	-630.599976
16	16	1	289	-423.269287
17	17	4	1156	-709.658691
18	18	8	2312	-6667.179199
19	19	22	6358	-55140.50855
20	20	67	19363	-95070.27539
21	21	1	289	-248.25354
22	22	1	289	-674.027588
23	23	1	289	-170.041504
24	24	1	289	-73.872803
25	25	2	578	-1029.844727
26	26	3	867	-2257.248047
27	27	1	289	-59.479248
28	28	1	289	-786.071533
29	29	4	1156	-489.310303
30	30	1	289	-156.565186
31	31	6	1734	-1231.213379
32	32	1	289	-222.888428
33	33	1	289	-24.059814
34	34	4	1156	-1880.616699
35	35	1	289	-800.465088
36	36	118	34102	-261777.343
37	37	2	578	-1093.8396
38	38	7	2023	-2580.750244
39	39	1	289	396.95166

100102921.2	CF
3707515.601	CY

Unique ID: CBC_72122821

Current Surface:

Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

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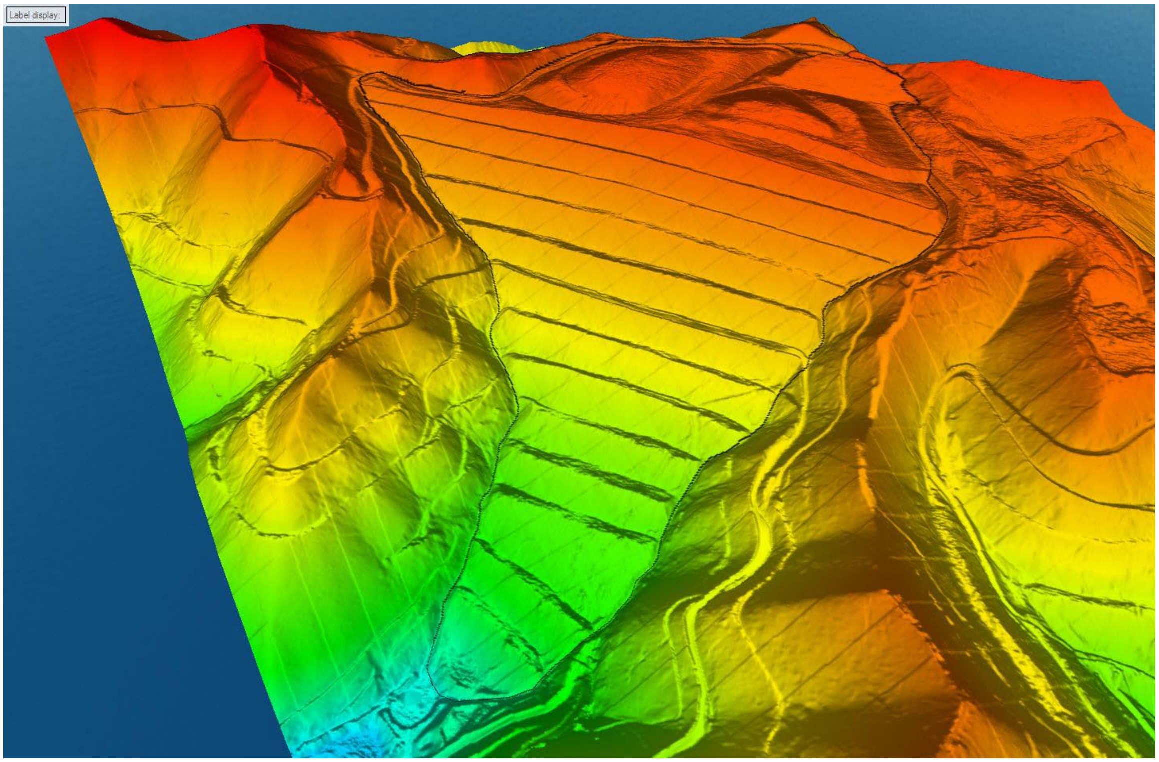
OBJECTID *	Value	Count	AREA	VOLUME
1	1	4	1156	191.279053
2	2	21	6069	-6963.799316
3	3	6866	1984274	102501536.4
4	4	1	289	-73.590576
5	5	12	3468	-12480.34082
6	6	1	289	-252.804443
7	7	3	867	-1254.567627
8	8	9	2601	-7384.528564
9	9	4	1156	-3372.113525
10	10	8	2312	-1792.209229
11	11	41	11849	-52188.1012
12	12	14	4046	-12222.9502
13	13	200	57800	-342783.3868
14	14	3	867	2056.831909
15	15	2	578	-2042.226685
16	16	13	3757	10730.00696
17	17	1	289	-74.860596
18	18	6	1734	-4059.793823
19	19	1	289	-359.344971
20	20	2	578	-337.472412
21	21	154	44506	169665.2959
22	22	19	5491	-13131.08472
23	23	1	289	-46.567383
24	24	5	1445	-3705.811157
25	25	1	289	-32.314941
26	26	1	289	-14.040771
27	27	1	289	-371.057373
28	28	2	578	-206.378174
29	29	1	289	-204.896484
30	30	2	578	-1913.319702
31	31	1	289	-409.369629
32	32	72	20808	-34271.82983
33	33	18	5202	-27539.87964
34	34	3	867	-292.633667
35	35	1	289	-2.716431
36	36	81	23409	-149719.9567
37	37	11	3179	-1764.621582
38	38	3	867	3153.387939
39	39	1	289	-25.82373
40	40	1	289	146.475586
41	41	1	289	193.748535
42	42	7	2023	1274.958496
43	43	1	289	184.152832
44	44	23	6647	-16120.56958
45	45	1	289	-227.333496
46	46	1	289	349.184814

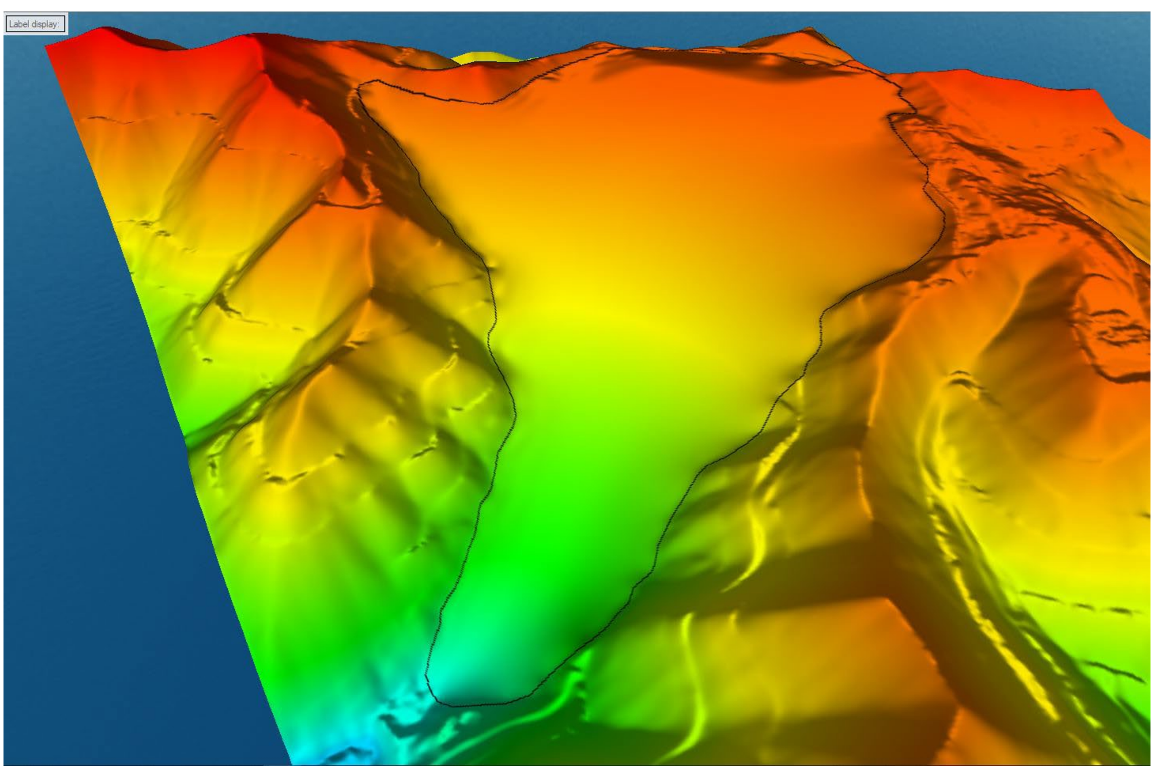
OBJECTID *	Value	Count	AREA	VOLUME	
				101991839.5	CF
				3777475.536	CY

Unique ID: CBC_72222107

Current Surface:



Historical Surface:



Process Documentation:

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OBJECTID *	Value	Count	AREA	VOLUME
1	1	1	49	-25.708252
2	2	4	196	-318.91272
3	3	2	98	-113.025391
4	4	4	196	-119.329834
5	5	1	49	-64.35437
6	6	1	49	-96.42688
7	7	1	49	-23.674561
8	8	1	49	-39.674927
9	9	3	147	-105.536621
10	10	1	49	-17.848633
11	11	1	49	-34.512939
12	12	2	98	-33.280762
13	13	1	49	-28.567383
14	14	1	49	-46.583496
15	15	2	98	-116.159668
16	16	11	539	-688.793335
17	17	1	49	-52.421387
18	18	2	98	-6.382202
19	19	2	98	-148.674805
20	20	1	49	-91.815186
21	21	4	196	-538.240356
22	22	2	98	-138.751587
23	23	6	294	-527.653198
24	24	1	49	-70.80835
25	25	1	49	-17.92041
26	26	68506	3356794	162073641.7
27	27	1	49	-11.364746
28	28	1	49	-8.039063
29	29	13	637	-827.939697
30	30	1	49	-131.155151
31	31	2	98	-99.890137
32	32	1	49	-5.126099
33	33	5	245	-217.156372
34	34	1	49	-21.826294
35	35	2	98	-204.140747
36	36	1	49	-6.244629
37	37	7	343	-574.272583
38	38	1	49	-3.68457
39	39	2	98	-10.491455
40	40	5	245	-369.4021
41	41	11	539	-1428.369141
42	42	2	98	-153.023315
43	43	7	343	-865.32373
44	44	6	294	-602.576782
45	45	2	98	-22.34668
46	46	1	49	-2.721558

OBJECTID *	Value	Count	AREA	VOLUME
47	47	2	98	-55.286499
48	48	1	49	-22.155273
49	49	10	490	-812.920288
50	50	1	49	-17.238525
51	51	1	49	-6.806885
52	52	21	1029	-1606.682007
53	53	3	147	-320.132935
54	54	1	49	-38.538452
55	55	1	49	-38.610229
56	56	18	882	-1291.112915
57	57	2	98	-33.179077
58	58	2	98	-14.81604
59	59	8	392	-537.187622
60	60	1	49	-1.142456
61	61	1	49	-68.164551
62	62	6	294	-418.473877
63	63	10	490	-1163.827759
64	64	1	49	-51.661743
65	65	38	1862	-6732.792603
66	66	1	49	-6.322388
67	67	92	4508	-8337.997192
68	68	1	49	-126.364014
69	69	12	588	-548.941162
70	70	9	441	-909.981201
71	71	2	98	-105.237549
72	72	1	49	-5.102173
73	73	1	49	-129.031738
74	74	3	147	-196.011963
75	75	1	49	-3.911865
76	76	9	441	-1185.360962
77	77	1	49	-5.778076
78	78	20	980	-1951.715698
79	79	776	38024	-132696.5579
80	80	2	98	152.837891
81	81	2	98	90.499268
82	82	3	147	-146.682983
83	83	1	49	-42.869019
84	84	4	196	-25.977417
85	85	1	49	-39.304077
86	86	2	98	-153.896606
87	87	1	49	-6.57959
88	88	1	49	-8.792725
89	89	17	833	-349.430054
90	90	8	392	-132.166016
91	91	1	49	-4.521973
92	92	1	49	-5.156006

OBJECTID *	Value	Count	AREA	VOLUME	
93	93	8	392	-226.547241	
94	94	9	441	-139.026733	
95	95	3	147	-82.980591	
96	96	423	20727	-61270.54028	
97	97	10	490	-262.932373	
98	98	1385	67865	-133325.6863	
99	99	1	49	12.866089	
100	100	1	49	-11.059692	
101	101	22	1078	-508.769775	
102	102	1	49	-3.744385	
103	103	31	1519	-574.583618	
104	104	17	833	-267.5979	
105	105	1	49	59.862305	
106	106	3	147	34.8479	
107	107	4	196	-27.383057	
108	108	2	98	-12.770386	
109	109	79	3871	-8286.114136	
110	110	1	49	-1.585083	
111	111	1	49	10.629028	
112	112	3	147	-6.352295	
113	113	128	6272	-3498.146606	
114	114	3	147	23.985596	
115	115	2	98	2.721558	
116	116	1	49	35.182861	
117	117	1	49	3.630737	
118	118	17	833	-532.575928	
119	119	5	245	-269.58374	
120	120	1	49	66.148804	
121	121	1	49	-10.59314	
122	122	12	588	-253.73291	
123	123	22	1078	-1054.53479	
124	124	2	98	-20.606079	
125	125	1	49	14.85791	
126	126	2	98	-33.896851	
				161694083.9	CF
				5988669.772	CY

Unique ID: CBC_72722556

Current Surface:

Historical Surface:

Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

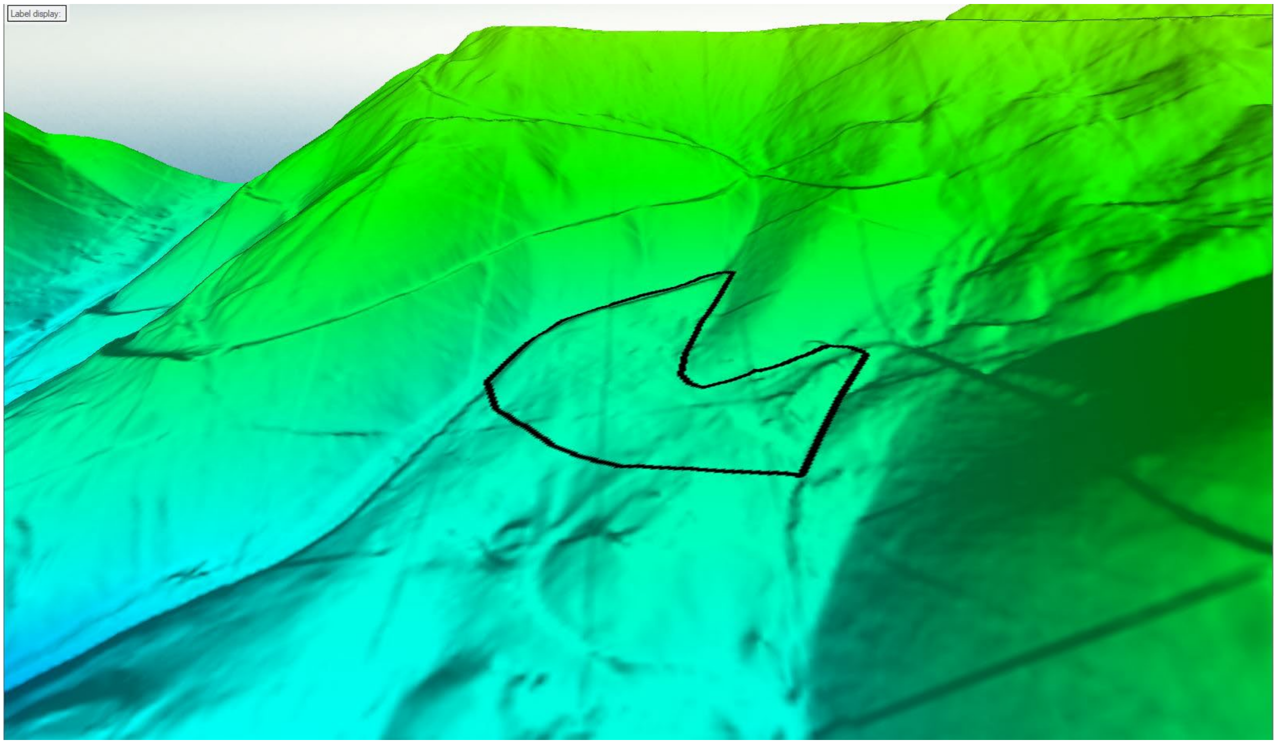
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

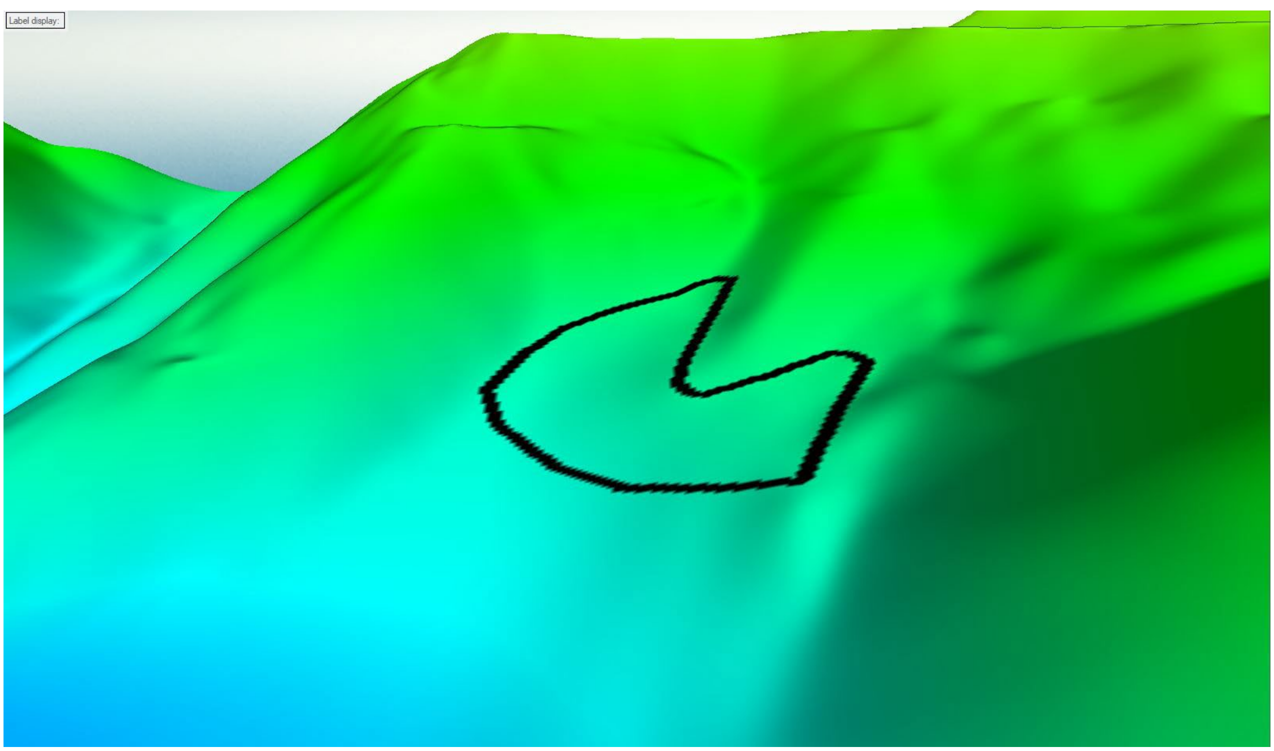
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	822	20550	-44636.3678	
2	2	550	13750	52393.27393	
3	3	1	25	6.695557	
4	4	1042	26050	189199.7925	
5	5	15	375	-411.865234	
6	6	1	25	-3.338623	
7	7	4	100	-94.476318	
8	8	18	450	-428.619385	
9	9	1	25	-4.992676	
10	10	45	1125	-2201.599121	
11	11	3	75	-42.150879	
12	12	1	25	7.000732	
13	13	1	25	-11.096191	
14	14	2	50	-19.812012	
15	15	8	200	-162.805176	
16	16	1	25	-12.567139	
17	17	1	25	4.449463	
18	18	1	25	2.380371	
19	19	1	25	-9.521484	
20	20	25	625	1224.822998	
21	21	1	25	3.369141	
				194802.5726	CF
				7214.910097	CY

Unique ID: CBC_72722608

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

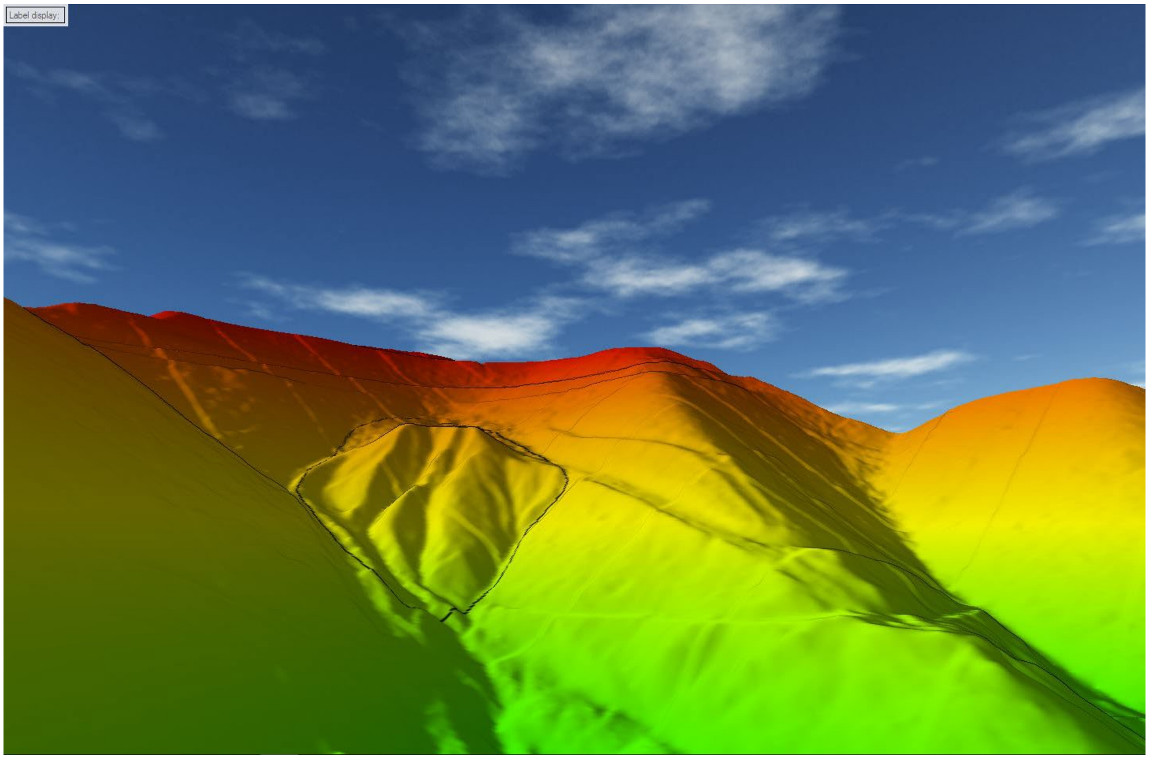
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

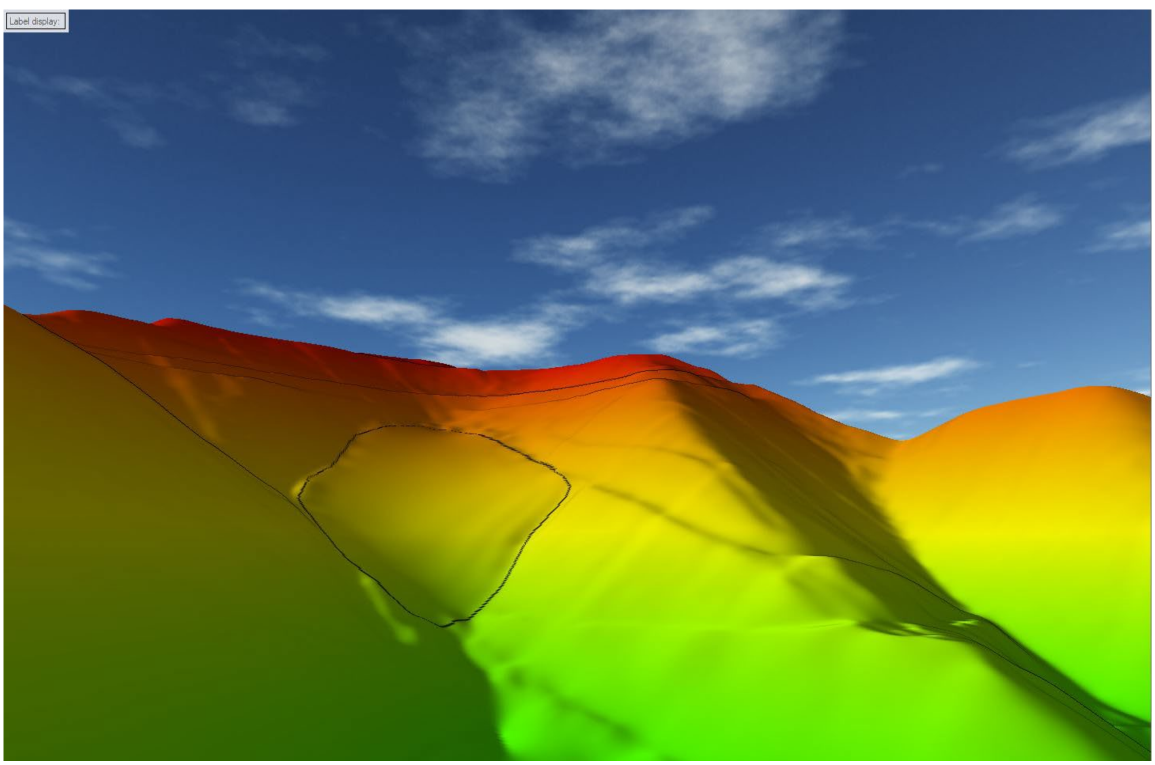
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	6	384	-208.210938	
2	2	720	46080	284531.0156	
3	3	1	64	-2.3125	
4	4	1	64	-12.90625	
5	5	10	640	-172.234375	
6	6	2	128	-24.625	
7	7	1	64	-0.890625	
8	8	2	128	-73.203125	
9	9	2	128	-83.546875	
10	10	3	192	-146.960938	
				283806.125	CF
				10511.33796	CY

Unique ID: CBC_72722648

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

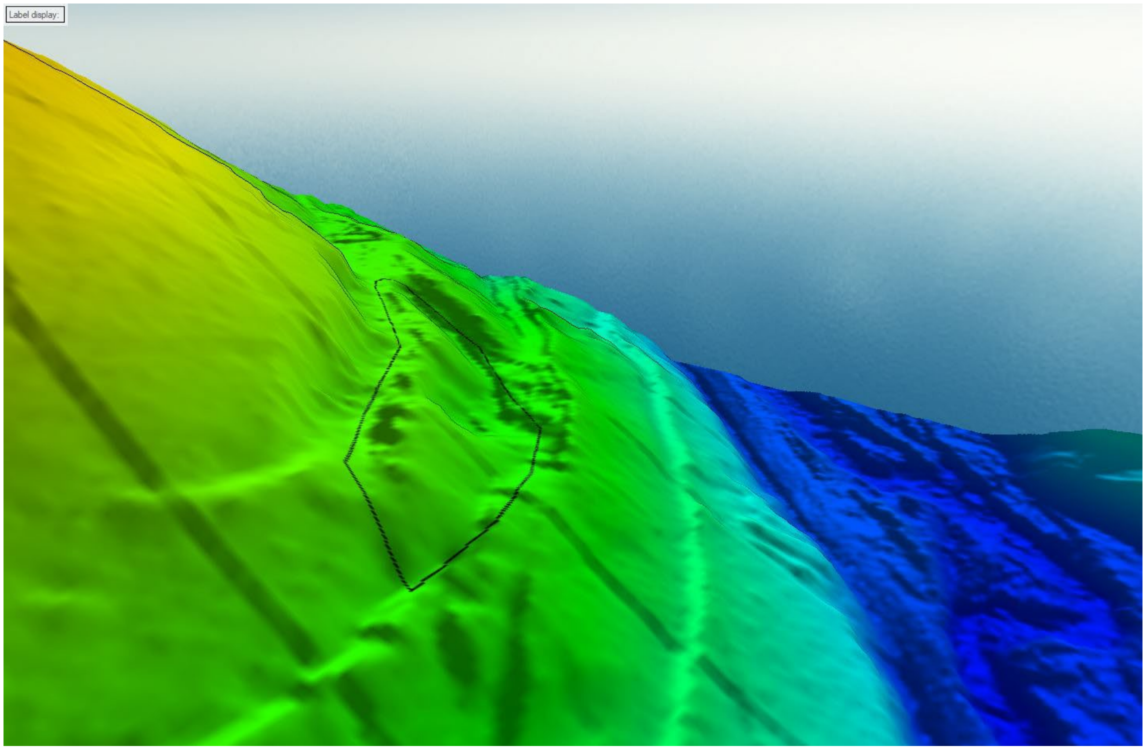
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

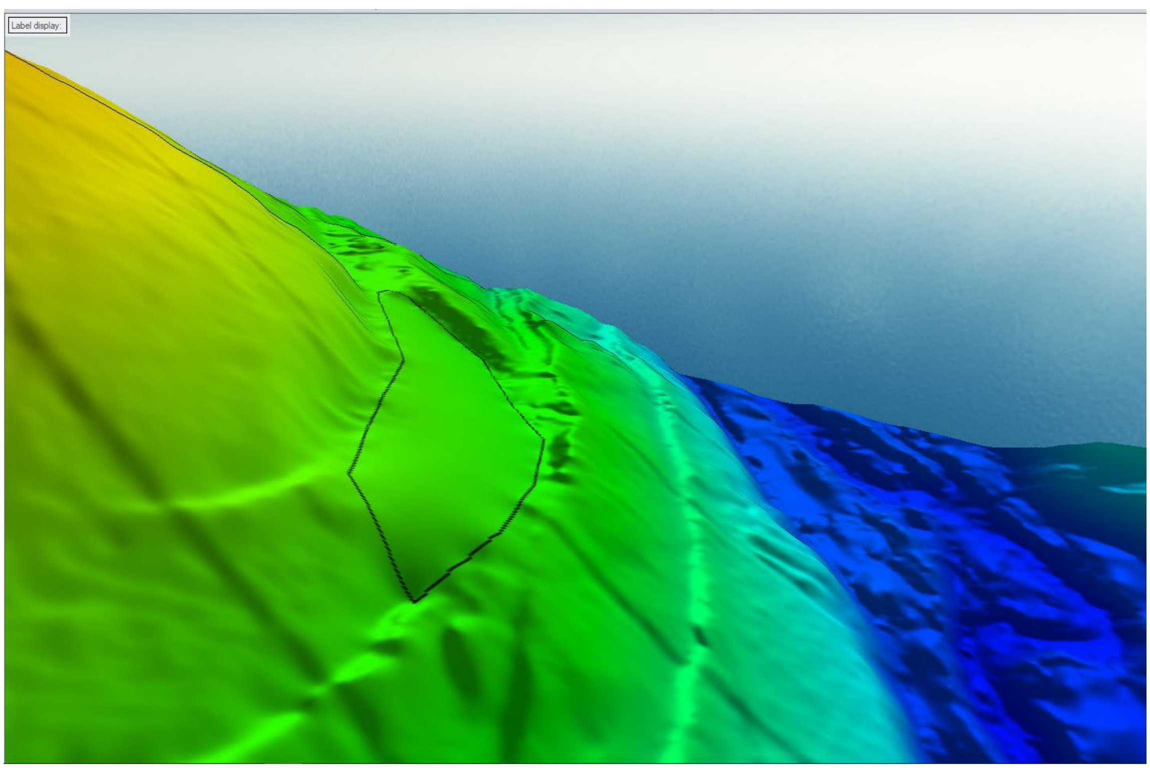
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	3	32.291602	9.024199	
2	2	71	764.234583	-520.938594	
3	3	10	107.638674	-86.460449	
4	4	6073	65368.96648	772266.6194	
5	5	3	32.291602	-14.692574	
6	6	1	10.763867	-0.070953	
7	7	1	10.763867	-0.286441	
8	8	2	21.527735	-0.454626	
9	9	1	10.763867	-1.532064	
10	10	301	3239.924076	-7021.547134	
11	11	1	10.763867	-0.643835	
12	12	13	139.930276	119.272375	
13	13	28	301.388286	-210.294854	
14	14	15	161.45801	-97.300526	
15	15	4	43.055469	-5.014028	
16	16	1	10.763867	-4.730215	
17	17	1	10.763867	-0.591277	
18	18	1	10.763867	-2.160132	
19	19	768	8266.650133	-22694.20052	
20	20	32	344.443756	492.102677	
21	21	11	118.402541	-51.146765	
22	22	3	32.291602	13.565206	
23	23	7	75.347072	-29.151265	
24	24	3	32.291602	19.03386	
				742178.4014	CF
				27488.08894	CY

Unique ID: CBC_72722650

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

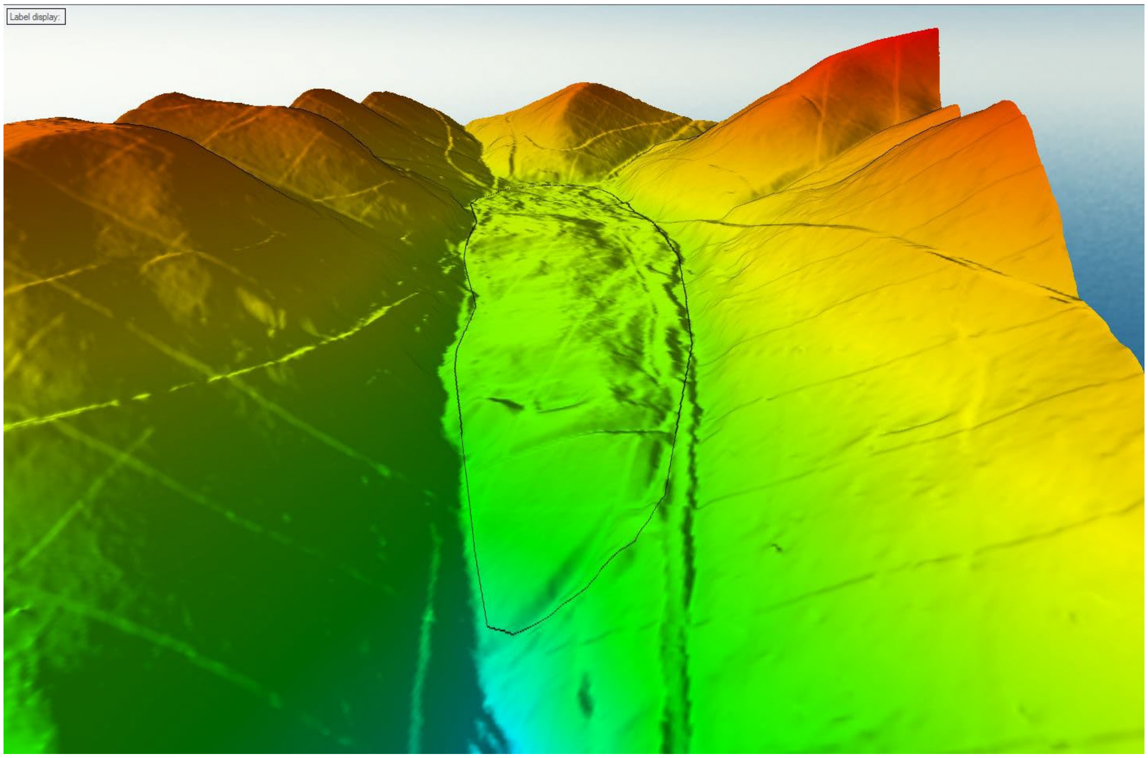
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

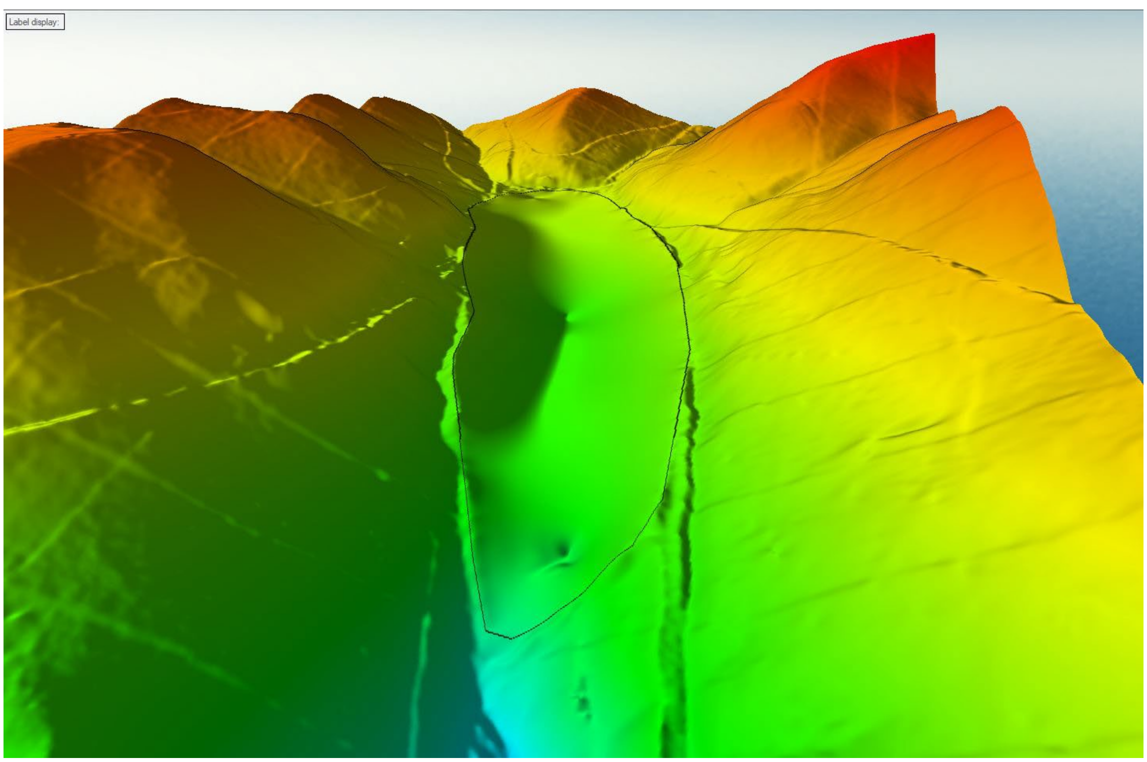
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	1067	11485.04647	49316.45711	
2	2	2	21.527735	9.568174	
3	3	3	32.291602	12.562663	
4	4	1	10.763867	6.410755	
5	5	1	10.763867	3.420208	
6	6	1	10.763867	0.438859	
7	7	1	10.763867	3.140337	
8	8	541	5823.252242	-17127.82787	
9	9	12	129.166408	65.033889	
10	10	1	10.763867	0.475649	
11	11	1	10.763867	0.829102	
12	12	1	10.763867	2.939303	
13	13	1	10.763867	3.878776	
14	14	1	10.763867	-0.817276	
				32296.50968	CF
				1196.167025	CY

Unique ID: CBC_72722715

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

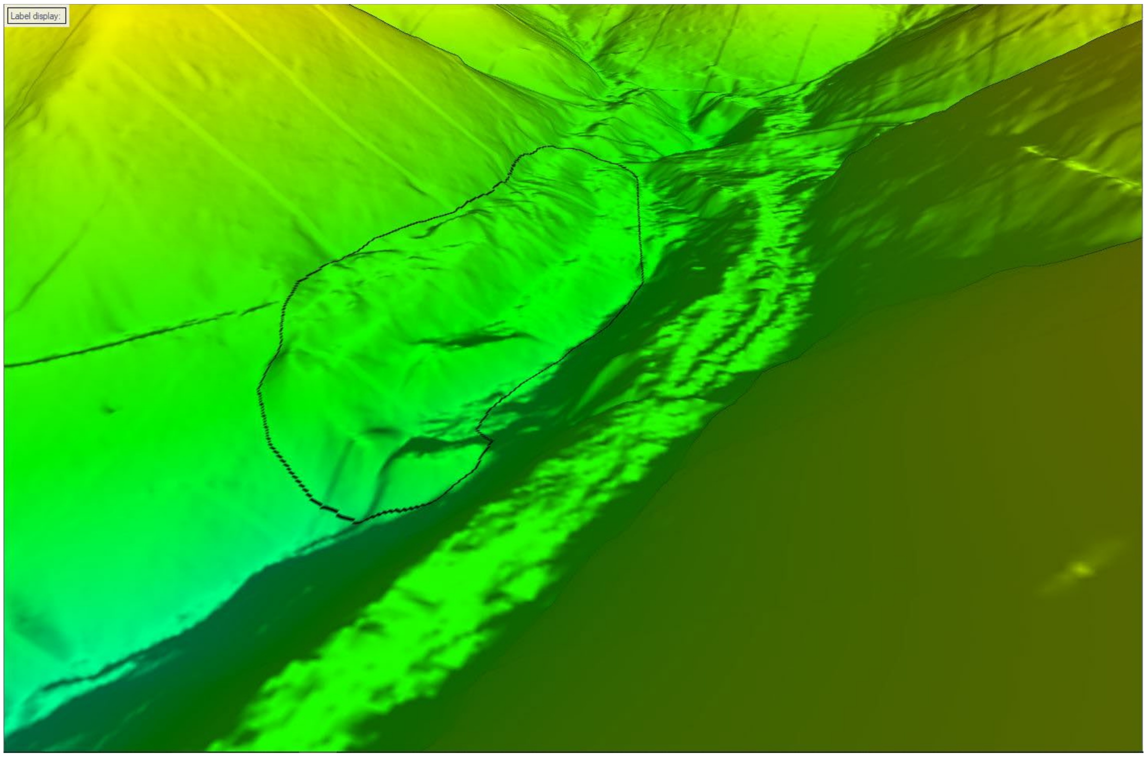
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	29206	314369.5101	7054381.426
2	2	3	32.291602	-7.222776
3	3	1	10.763867	-0.321917
4	4	13	139.930276	-31.145839
5	5	3	32.291602	-3.878776
6	6	3	32.291602	-10.319753
7	7	1	10.763867	-1.315263
8	8	1	10.763867	-0.949985
9	9	1	10.763867	-1.811935
10	10	1	10.763867	-1.656889
11	11	8	86.110939	-13.115835
12	12	1	10.763867	-0.706904
13	13	1	10.763867	-0.127453
14	14	44	473.610164	-414.356335
15	15	1	10.763867	-4.487135
16	16	1	10.763867	-1.794854
17	17	1	10.763867	-4.019369
18	18	2	21.527735	-6.276733
19	19	10	107.638674	-14.679434
20	20	1	10.763867	-0.747637
21	21	1	10.763867	-0.589963
22	22	8	86.110939	-16.558381
23	23	1	10.763867	2.714618
24	24	4	43.055469	-12.337978
25	25	8	86.110939	-23.268717
26	26	1	10.763867	-1.415123
27	27	1	10.763867	-0.070953
28	28	1	10.763867	-5.023226
29	29	1	10.763867	-1.214089
30	30	57	613.54044	-658.018915
31	31	1	10.763867	-0.863264
32	32	4	43.055469	-32.936751
33	33	5	53.819337	12.475942
34	34	36	387.499225	-345.141462
35	35	2	21.527735	-5.812909
36	36	1	10.763867	-2.415038
37	37	95	1022.567399	-1658.245246
38	38	1	10.763867	-0.017081
39	39	2	21.527735	-3.562115
40	40	3	32.291602	24.117528
41	41	1	10.763867	0.846183
42	42	7	75.347072	39.595843
43	43	5	53.819337	29.140753
				7051203.891 CF
				261155.6997 CY

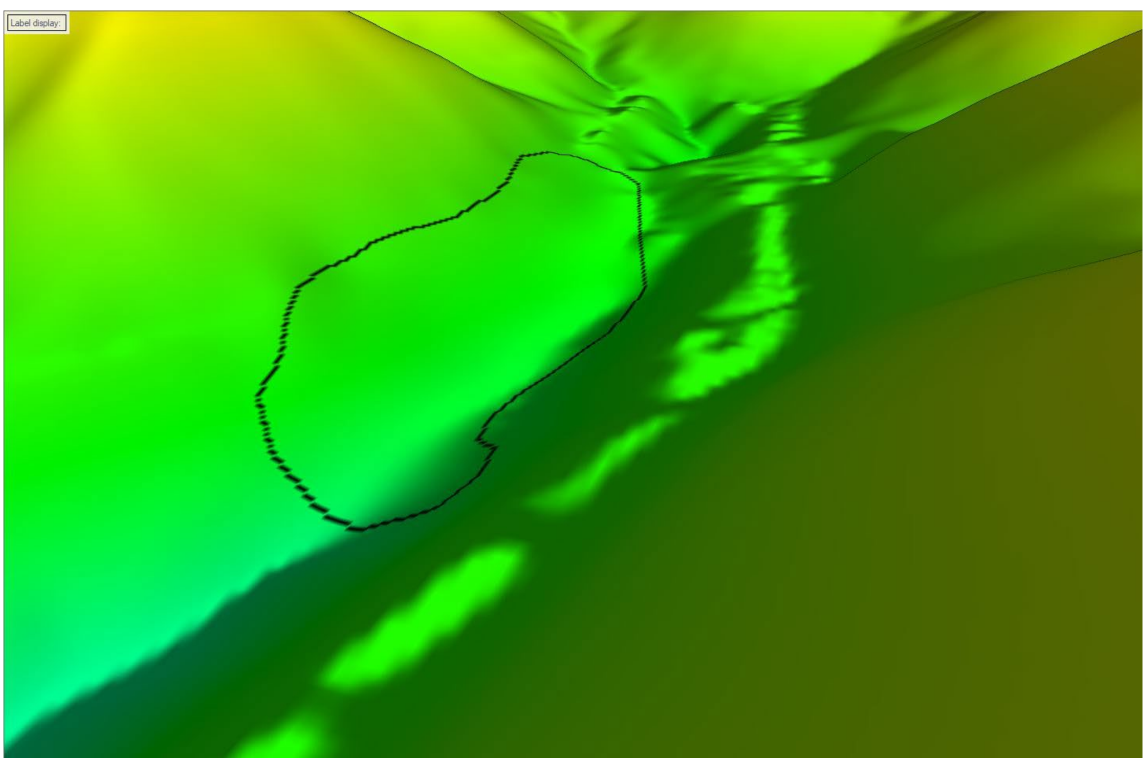
OBJECTID *	Value	Count	AREA	VOLUME

Unique ID: CBC_72722812

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

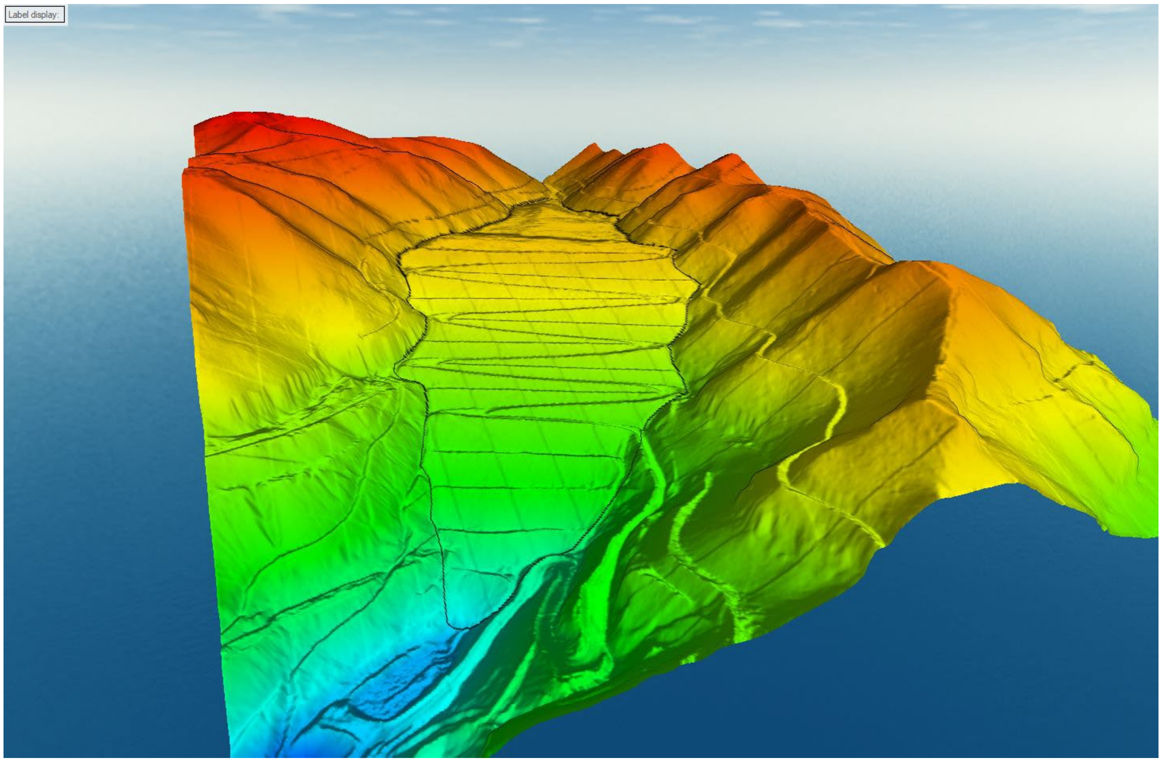
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

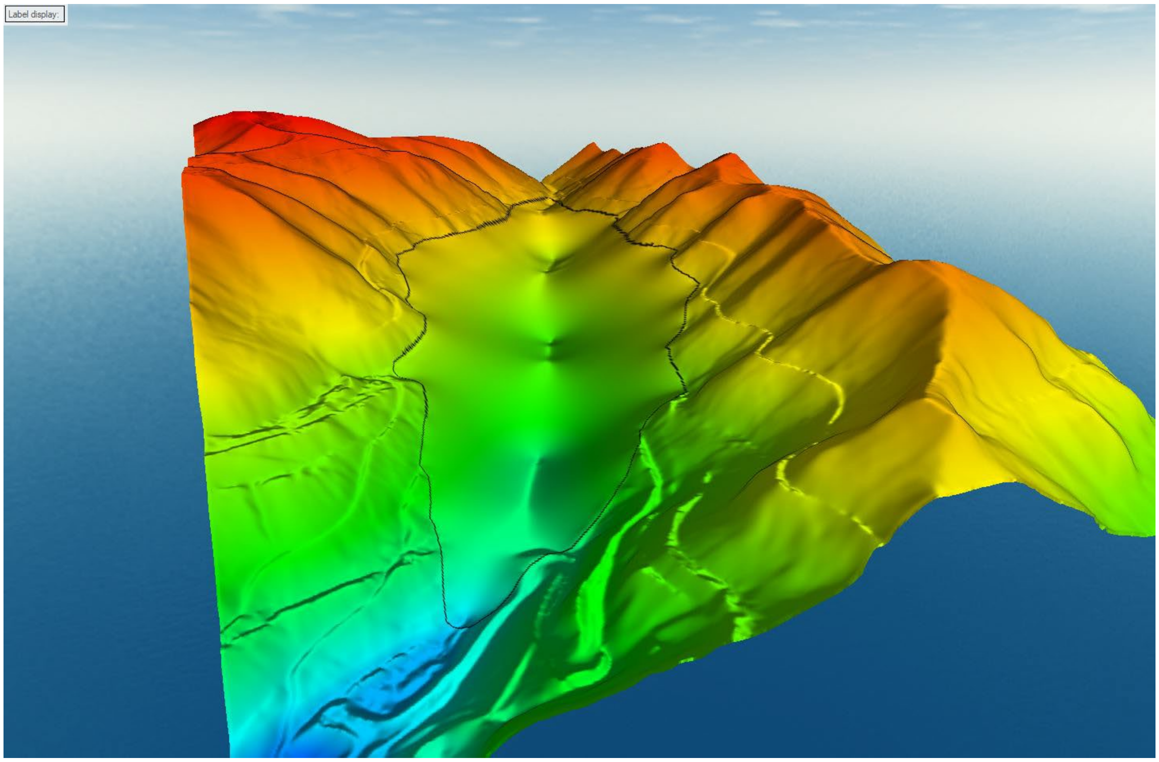
Rowid	VALUE	COUNT	AREA	VOLUME	
8	9	21	1344	-1278.140625	
3	4	214	13696	-1000	
1	2	11	704	-741.304688	
9	10	11	704	-362	
6	7	2	128	-169.773438	
10	11	1	64	-64.265625	
7	8	3	192	-48.554688	
4	5	1	64	-27.914063	
5	6	2	128	-15.75	
2	3	1	64	-10.0625	
11	12	1	64	10.460938	
0	1	1279	81856	541368.8516	
				537661.5469	CF
				19913.39062	CY

Unique ID: CBC_72922323

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

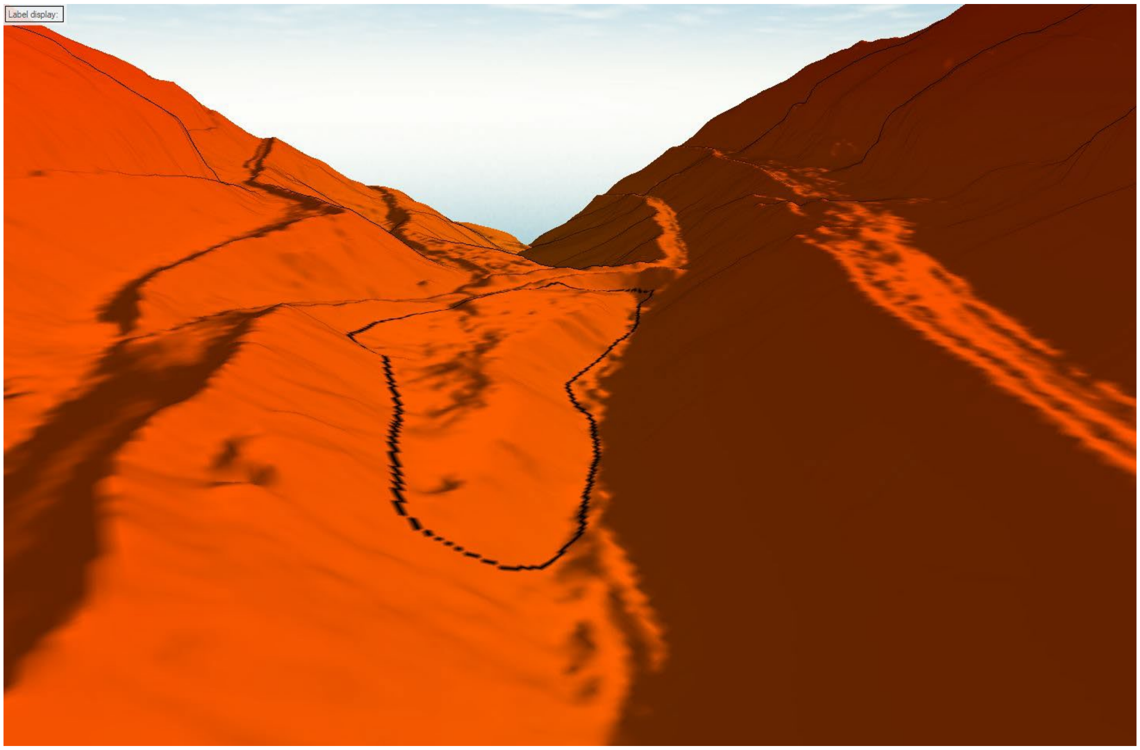
OBJECTID *	Value	Count	AREA	VOLUME
1	1	8	128	-164.412109
2	2	98403	1574448	138598717.9
3	3	1	16	-0.011719
4	4	3	48	-49.408203
5	5	3	48	-51.056641
6	6	10	160	-70.982422
7	7	1	16	-2.205078
8	8	2	32	-12.554688
9	9	2	32	-16.578125
10	10	5	80	-38.445313
11	11	2	32	-8.814453
12	12	1	16	-4.400391
13	13	2	32	-11.201172
14	14	5	80	-21.271484
15	15	1	16	-2.869141
16	16	1	16	-13.753906
17	17	4	64	-54.222656
18	18	2	32	-7.576172
19	19	17	272	-149.902344
20	20	2	32	-23.722656
21	21	1	16	-2.400391
22	22	19	304	-183.095703
23	23	1	16	-13.332031
24	24	135	2160	-6231.13672
25	25	1	16	0.871094
26	26	6	96	-43.058594
27	27	1	16	-9.367188
28	28	1	16	-6.132813
29	29	1	16	-10.351563
30	30	1	16	-5.480469
31	31	1	16	-0.6875
32	32	16	256	-139.707031
33	33	3	48	-41.400391
34	34	1	16	-10.640625
35	35	1	16	-7.695313
36	36	2	32	-22.59375
37	37	3	48	-43.777344
38	38	2	32	-7.644531
39	39	2	32	-14.539063
40	40	304	4864	-17501.4473
41	41	13	208	-262.449219
42	42	1	16	4.794922
43	43	3	48	-13.296875
44	44	1	16	-0.558594
45	45	1	16	-9.507813
46	46	1	16	-4.601563

OBJECTID *	Value	Count	AREA	VOLUME
47	47	2	32	-4.660156
48	48	1	16	-4.199219
49	49	1	16	-4.089844
50	50	12	192	107.974609
51	51	1	16	-10.484375
52	52	1	16	-4.957031
53	53	1	16	-12.605469
54	54	1	16	-2.820313
55	55	17	272	-359.777344
56	56	1	16	-4.164063
57	57	8	128	-111.996094
58	58	8	128	-92.320313
59	59	2	32	-5.074219
60	60	3	48	-36.773438
61	61	1	16	-12.253906
62	62	1	16	0.8125
63	63	5	80	-62.277344
64	64	1	16	-0.474609
65	65	2	32	-43.238281
66	66	1	16	-3.029297
67	67	3	48	-36.132813
68	68	2	32	-32.578125
69	69	1	16	-7.53125
70	70	1	16	-7.5625
71	71	1	16	-5.910156
72	72	1	16	-7.53125
73	73	1	16	-9.242188
74	74	8	128	-71.001953
75	75	2	32	-16.140625
76	76	23	368	-322.878906
77	77	1	16	1.138672
78	78	1	16	-0.917969
79	79	21	336	-422.085938
80	80	165	2640	-7327.41016
81	81	4	64	-40.671875
82	82	6	96	-24.285156
83	83	2	32	-16.128906
84	84	1	16	-1.429688
85	85	2	32	-10.875
86	86	1	16	-12.371094
87	87	1	16	-22.523438
88	88	2	32	-6.753906
89	89	1	16	-8.117188
90	90	1	16	-4.144531
91	91	1	16	-5.710938
92	92	1	16	-2.46875

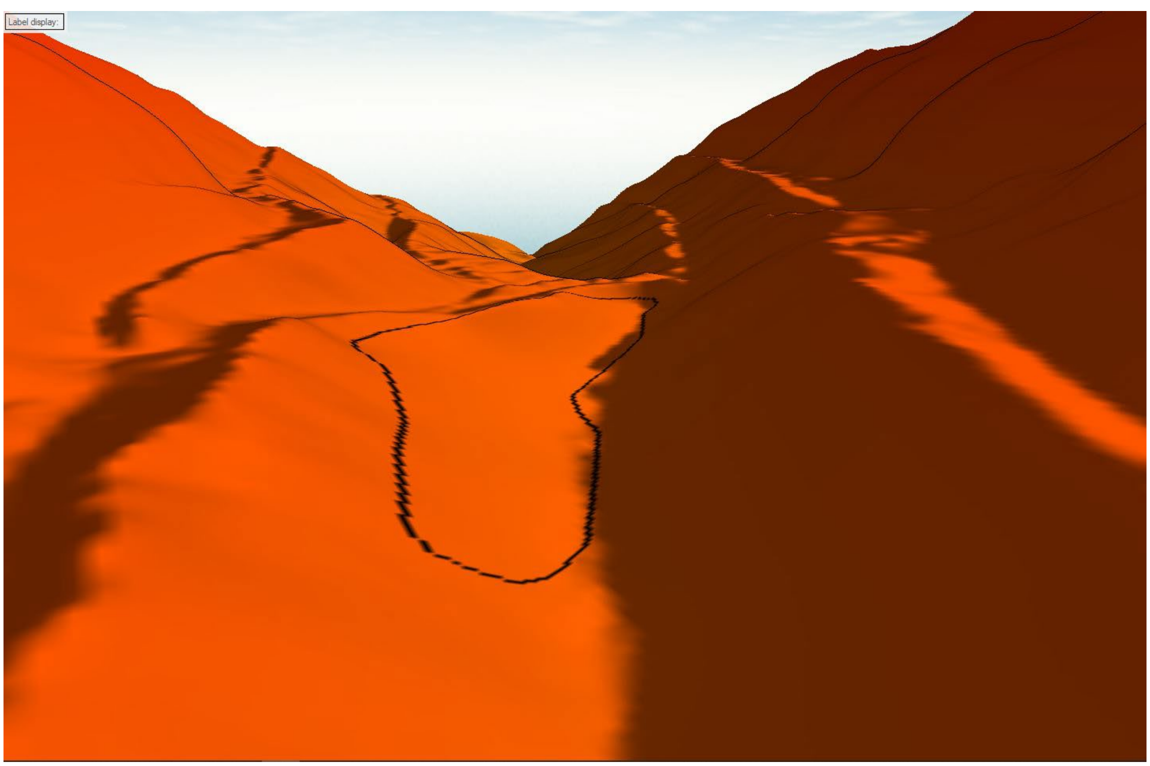
OBJECTID *	Value	Count	AREA	VOLUME
93	93	1	16	-3.808594
94	94	2	32	-4.757813
95	95	2	32	-10.0625
96	96	1	16	-6.230469
97	97	1	16	-6.671875
98	98	1	16	-8.296875
99	99	1	16	-9.089844
100	100	2	32	-18.160156
101	101	13	208	-112.121094
102	102	1	16	-3.375
103	103	4	64	-11.941406
104	104	4	64	-14.652344
105	105	8	128	-51.421875
106	106	2	32	-3.519531
107	107	1	16	-3.570313
108	108	49	784	-1100.37109
109	109	31	496	-512.453125
110	110	3	48	13.289063
111	111	1	16	-0.148438
112	112	1	16	-4.566406
113	113	2	32	-9.867188
114	114	14	224	-244.496094
115	115	9	144	-96.21875
116	116	1	16	-2.414063
117	117	1	16	-6.75
118	118	1	16	-1.238281
119	119	11	176	-130.472656
120	120	14	224	-145.144531
121	121	8	128	-80.1875
122	122	4	64	-48.203125
123	123	1	16	-4.640625
124	124	3	48	-26.738281
125	125	2	32	-13.375
126	126	8	128	-43.710938
127	127	3	48	-12.335938
128	128	16	256	-220.78125
129	129	2	32	-23.808594
130	130	6	96	-29.347656
131	131	13	208	-171.4375
132	132	1	16	-3.078125
133	133	1	16	5.449219
				138561166.8 CF
				5131895.068 CY

Unique ID: CBC_72922735

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

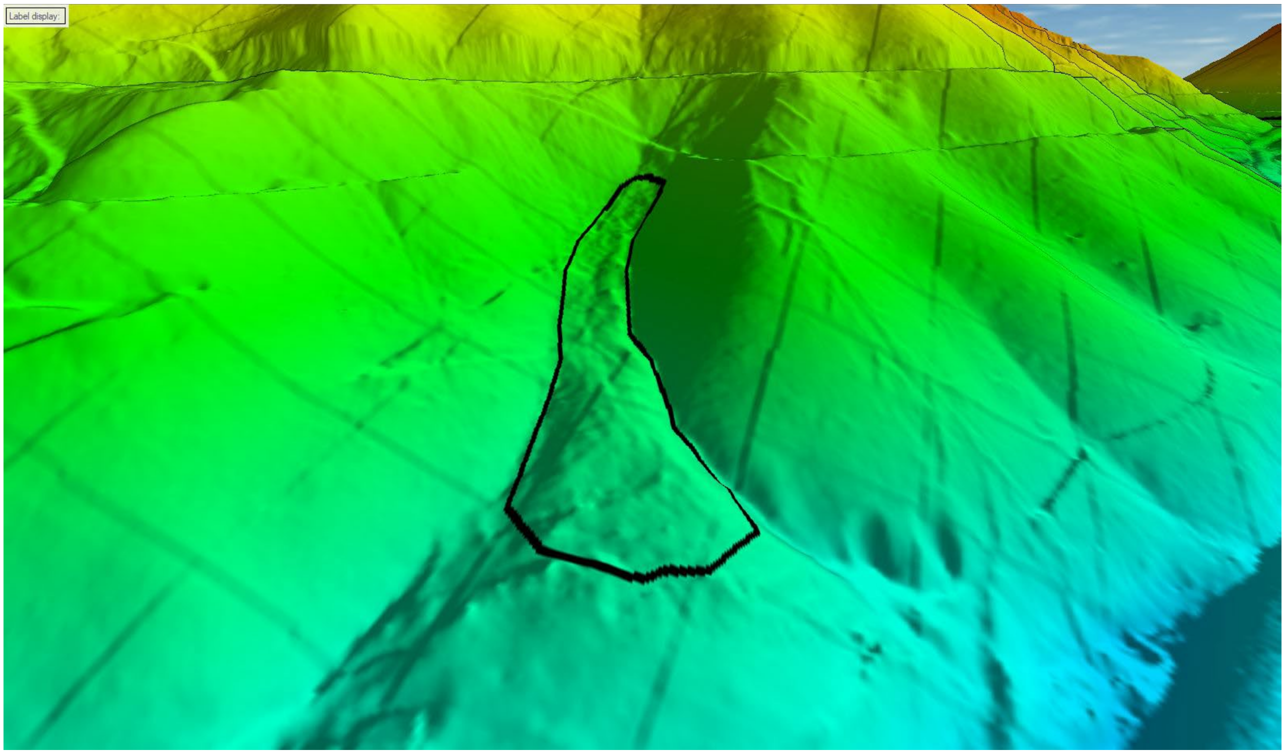
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

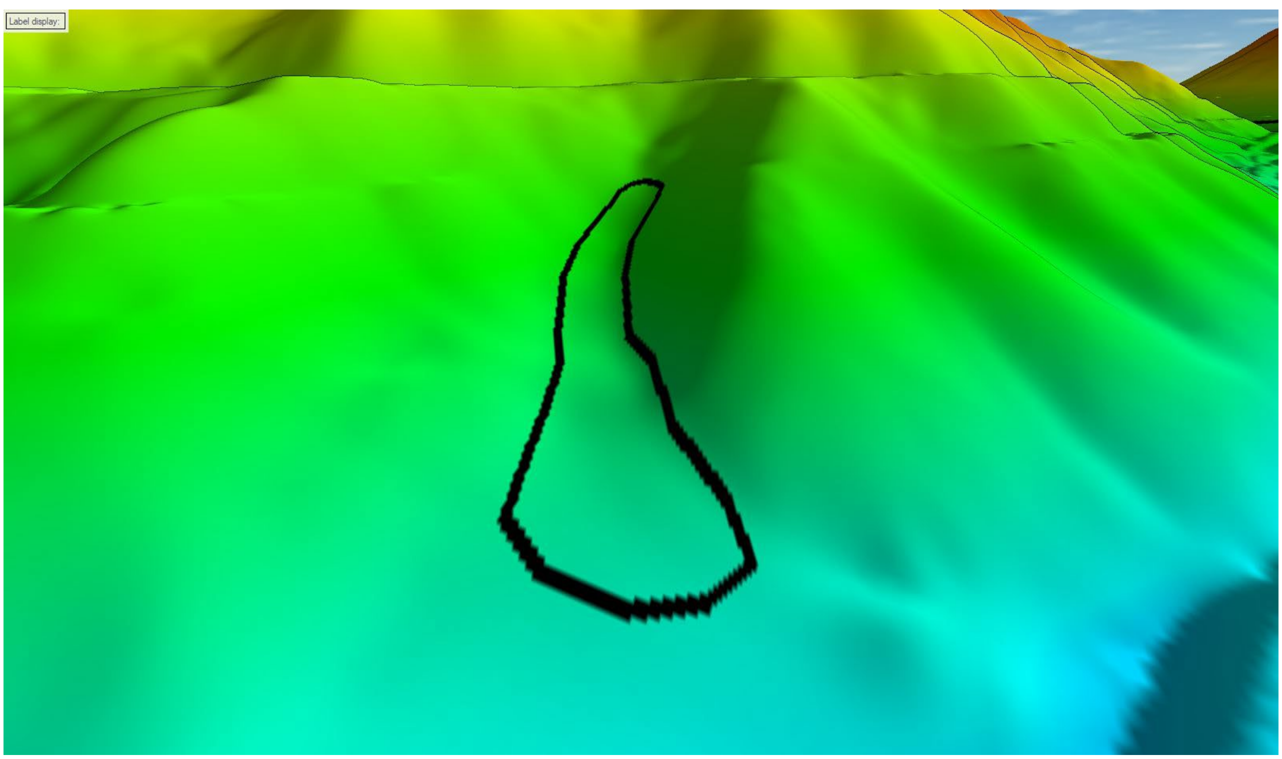
OBJECTID *	Value	Count	AREA	VOLUME
1	1	67	1675	-2191.607666
2	2	1	25	4.064941
3	3	1347	33675	233524.1577
4	4	1	25	18.621826
5	5	1	25	0.958252
6	6	3	75	-23.7854
7	7	1	25	-9.484863
8	8	6	150	-67.138672
9	9	4	100	-60.48584
10	10	1	25	14.782715
11	11	62	1550	-2007.678223
12	12	1	25	8.117676
13	13	8	200	-137.548828
14	14	3	75	-26.184082
15	15	1	25	-12.133789
16	16	32	800	-734.161377
17	17	4	100	-26.953125
18	18	3	75	-38.378906
19	19	1	25	6.378174
				228241.5405 CF
				8453.39039 CY

Unique ID: CBC_72922747

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

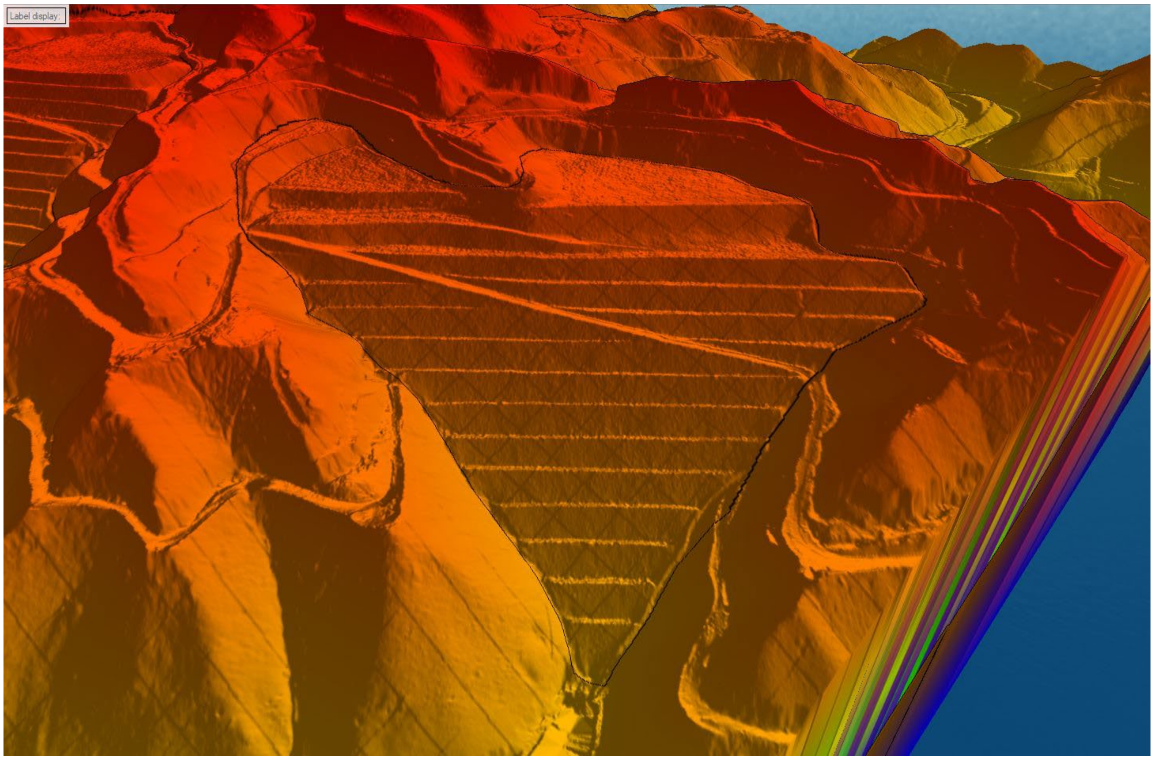
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

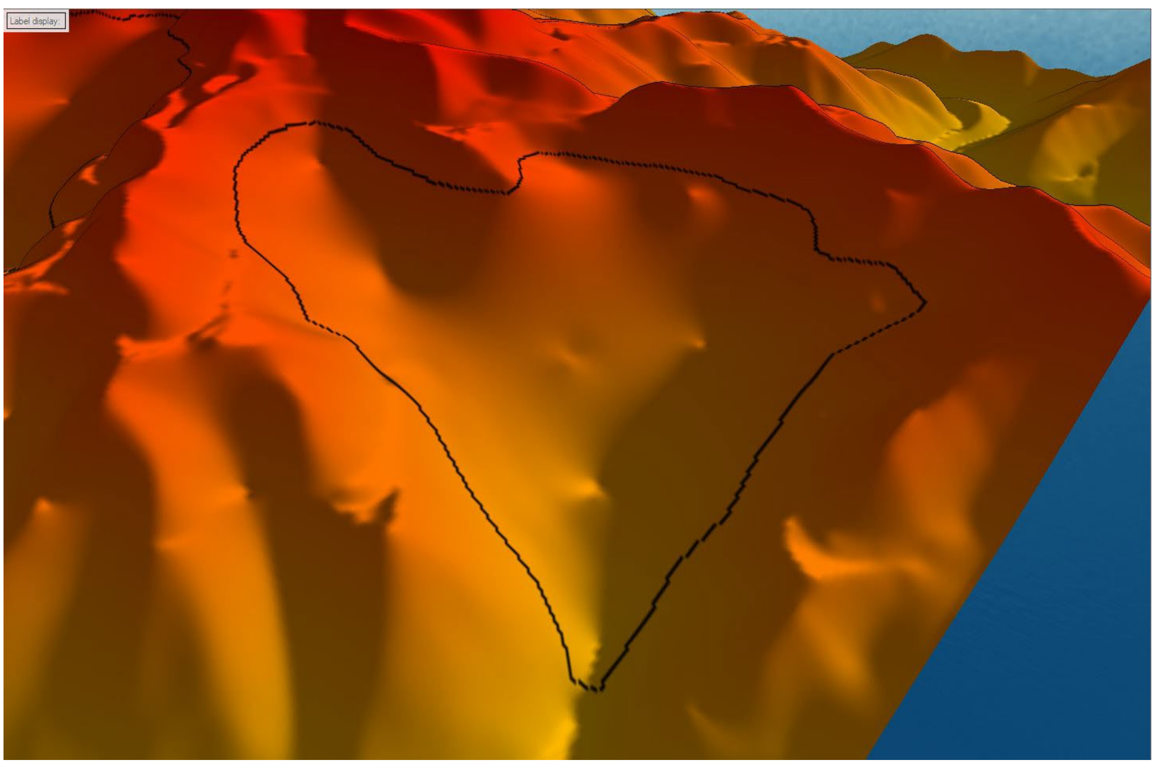
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	200	12800	-24200.96875	
2	2	1	64	10.070313	
3	3	4	256	112.109375	
4	4	6	384	235.015625	
5	5	490	31360	286682.2891	
6	6	2	128	16.710938	
7	7	7	448	-516.273438	
8	8	4	256	-191.421875	
9	9	3	192	-140.632813	
10	10	3	192	-131.242188	
11	11	1	64	-13.632813	
12	12	2	128	-292.1875	
13	13	4	256	-399.6875	
14	14	1	64	-111.875	
15	15	4	256	-250.726563	
16	16	1	64	-41.398438	
				260766.1484	CF
				9658.005498	CY

Unique ID: CBC_73122742

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

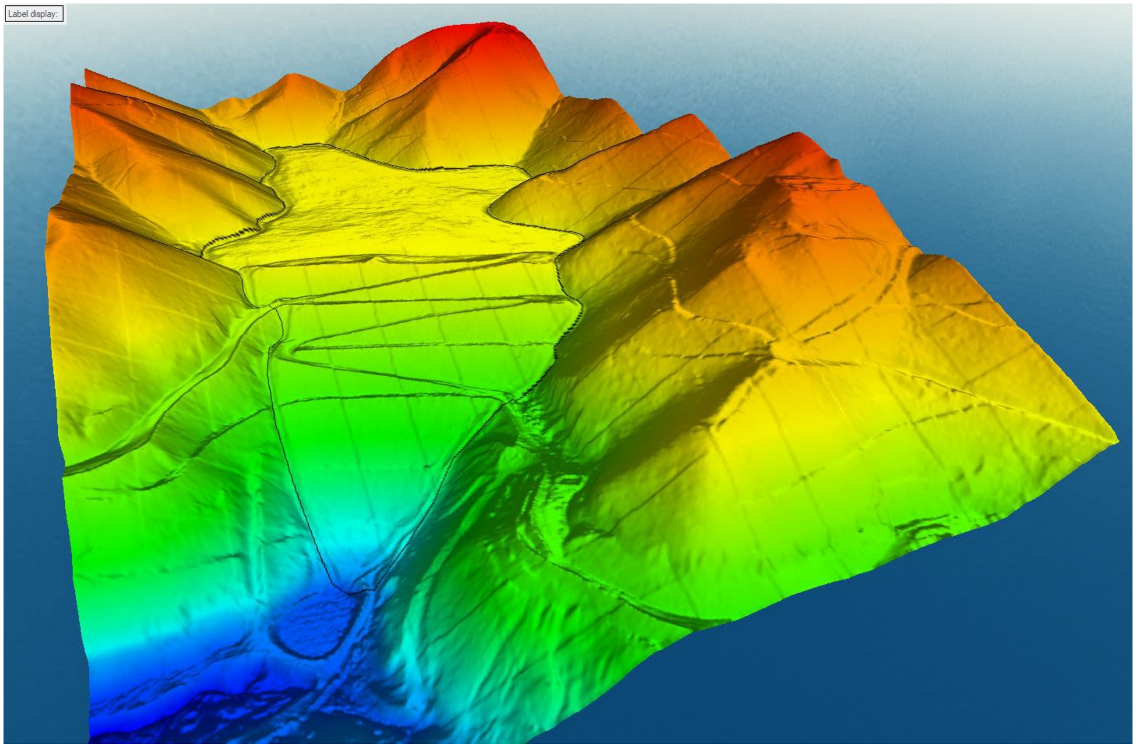
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	16	4624	-21621.5886
2	2	8	2312	-9442.17188
3	3	1	289	-250.334961
4	4	69	19941	-134929.874
5	5	2	578	-3102.90466
6	6	2	578	-1842.26917
7	7	1	289	-897.304077
8	8	7	2023	-10055.3796
9	9	7	2023	-9907.8457
10	10	8329	2407081	174901350.3
11	11	4	1156	-6450.25281
12	12	5	1445	-4448.1023
13	13	1	289	-161.433594
14	14	1	289	-302.264648
15	15	1	289	-385.415649
16	16	1	289	-807.203247
17	17	2	578	-339.024658
18	18	2	578	-2213.36182
19	19	1	289	-542.368896
20	20	3	867	-1997.52905
21	21	1	289	-57.644775
22	22	1	289	-419.529785
23	23	1	289	-410.286865
24	24	1	289	-83.680176
25	25	1	289	-518.238525
26	26	9	2601	-6377.40308
27	27	1	289	-320.821045
28	28	1	289	-64.241821
29	29	1	289	-323.078857
30	30	1	289	-222.253418
31	31	26	7514	-37940.5635
32	32	17	4913	-24939.0913
33	33	4	1156	-5532.48731
34	34	4	1156	-4282.99976
35	35	1	289	-460.240967

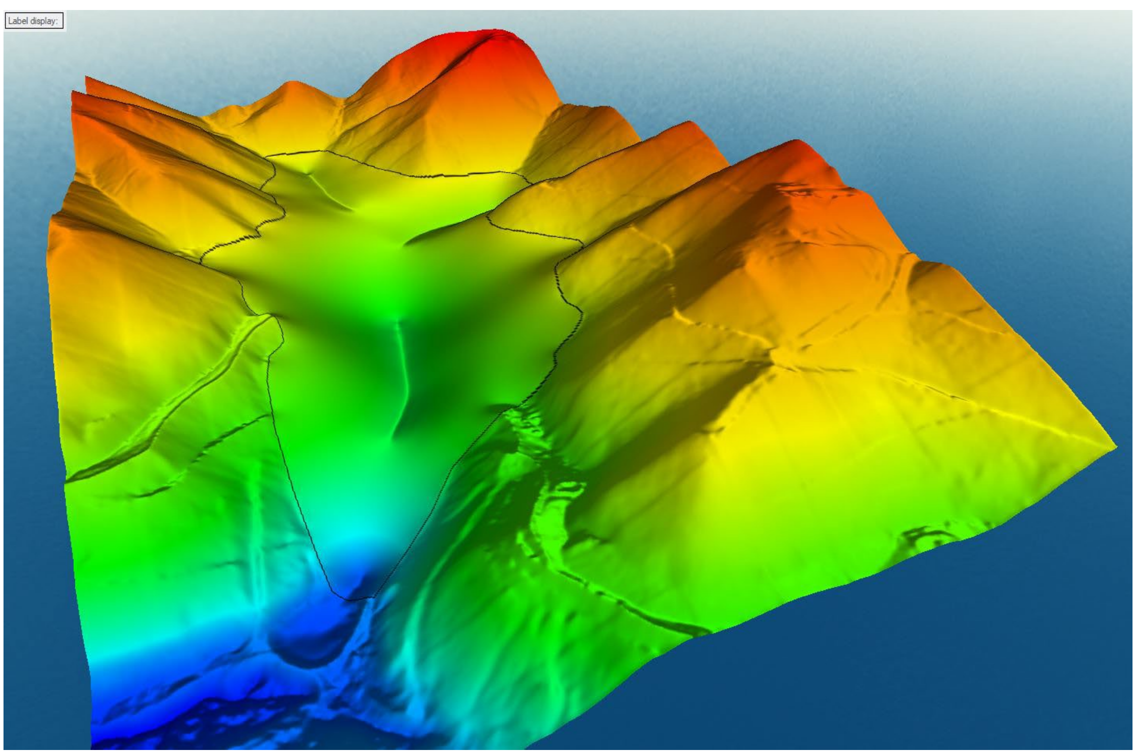
174609701.1	CF
6467025.966	CY

Unique ID: CBC_80122229

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

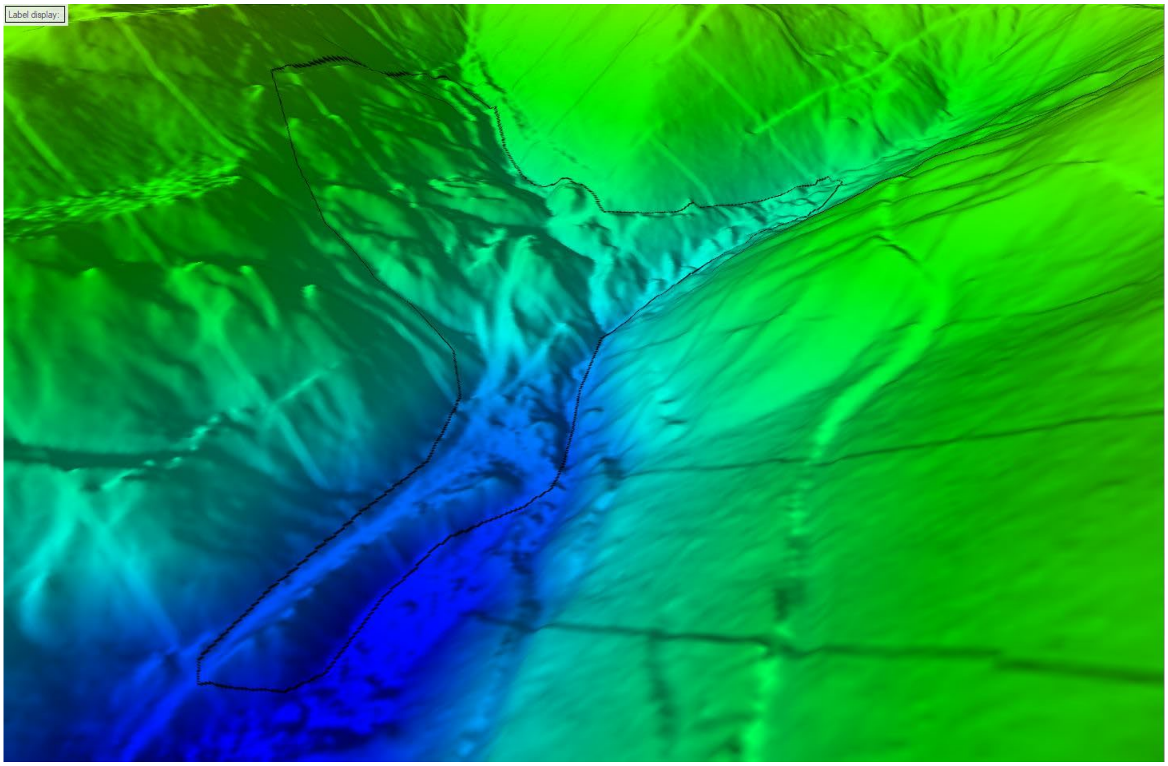
OBJECTID *	Value	Count	AREA	VOLUME
1	1	1	10.76387	4.317635
2	2	295	3175.341	-4421.20071
3	3	4	43.05547	10.950448
4	4	1	10.76387	2.047132
5	5	19	204.5135	67.345124
6	6	110378	1188094	69602084.48
7	7	30	322.916	294.889496
8	8	5	53.81934	-37.802303
9	9	1	10.76387	-3.411011
10	10	6	64.5832	-27.330132
11	11	82	882.6371	-971.157844
12	12	14	150.6941	-88.073978
13	13	1	10.76387	-0.840927
14	14	1	10.76387	-0.170813
15	15	1	10.76387	-1.090577
16	16	2	21.52774	-1.73704
17	17	4	43.05547	-11.377481
18	18	1	10.76387	1.976179
19	19	10	107.6387	-52.41604
20	20	23	247.5689	-504.903165
21	21	10	107.6387	-56.587827
22	22	1	10.76387	-1.198321
23	23	1	10.76387	-2.175899
24	24	2	21.52774	-5.923281
25	25	9	96.87481	91.285269
26	26	10	107.6387	-32.974855
27	27	9	96.87481	47.733127
28	28	1	10.76387	-4.447716
29	29	1	10.76387	5.505445
30	30	13	139.9303	-52.594737
31	31	4	43.05547	-6.858812
32	32	1	10.76387	-1.158903
33	33	1	10.76387	0.888229
34	34	1	10.76387	1.18781
35	35	1	10.76387	4.753866
36	36	3	32.2916	22.691893
37	37	1	10.76387	-0.189209
38	38	3	32.2916	9.376338
39	39	452	4865.268	-7846.60177
40	40	7	75.34707	28.315593
41	41	34	365.9715	-151.369513
42	42	1	10.76387	1.78697
43	43	27	290.6244	-104.230291
44	44	1	10.76387	2.82499
45	45	15	161.458	-61.66361
46	46	4	43.05547	-4.467425

OBJECTID *	Value	Count	AREA	VOLUME
47	47	5	53.81934	-26.105532
48	48	1	10.76387	-1.27453
49	49	64	688.8875	-781.413147
50	50	3	32.2916	-3.255965
51	51	4	43.05547	-7.754925
52	52	8	86.11094	-30.018471
53	53	2	21.52774	-4.593564
54	54	2	21.52774	-4.993005
55	55	1	10.76387	-1.111601
56	56	1	10.76387	-0.268046
57	57	1	10.76387	-0.404696
58	58	1	10.76387	-2.005086
59	59	2	21.52774	-3.219174
60	60	19	204.5135	-123.621545
61	61	1	10.76387	-2.375619
62	62	1	10.76387	-1.789598
63	63	67	721.1791	-378.976954
64	64	108	1162.498	-3436.55649
65	65	1	10.76387	-9.155594
66	66	6	64.5832	-35.439823
67	67	67	721.1791	-582.872878
68	68	1	10.76387	-9.662778
69	69	9	96.87481	-91.361478
70	70	2	21.52774	-14.689946
71	71	1	10.76387	0.228627
72	72	2	21.52774	-7.72339
73	73	1	10.76387	-0.609672
74	74	3	32.2916	-2.696223
75	75	11	118.4025	-108.574205
76	76	1	10.76387	-3.014198
77	77	3	32.2916	-11.305214
78	78	4	43.05547	-25.787556
79	79	5	53.81934	-38.277952
80	80	7	75.34707	-63.855277
81	81	3	32.2916	-8.196412
82	82	1	10.76387	-6.349
83	83	1	10.76387	-1.955156
84	84	1	10.76387	-0.425719
85	85	1	10.76387	-2.606874
86	86	1	10.76387	-0.930276
87	87	1	10.76387	-0.173441
88	88	1	10.76387	-0.126139
89	89	2	21.52774	-9.173989
90	90	2	21.52774	-3.350569
91	91	3	32.2916	-12.923999
92	92	1	10.76387	-3.810451

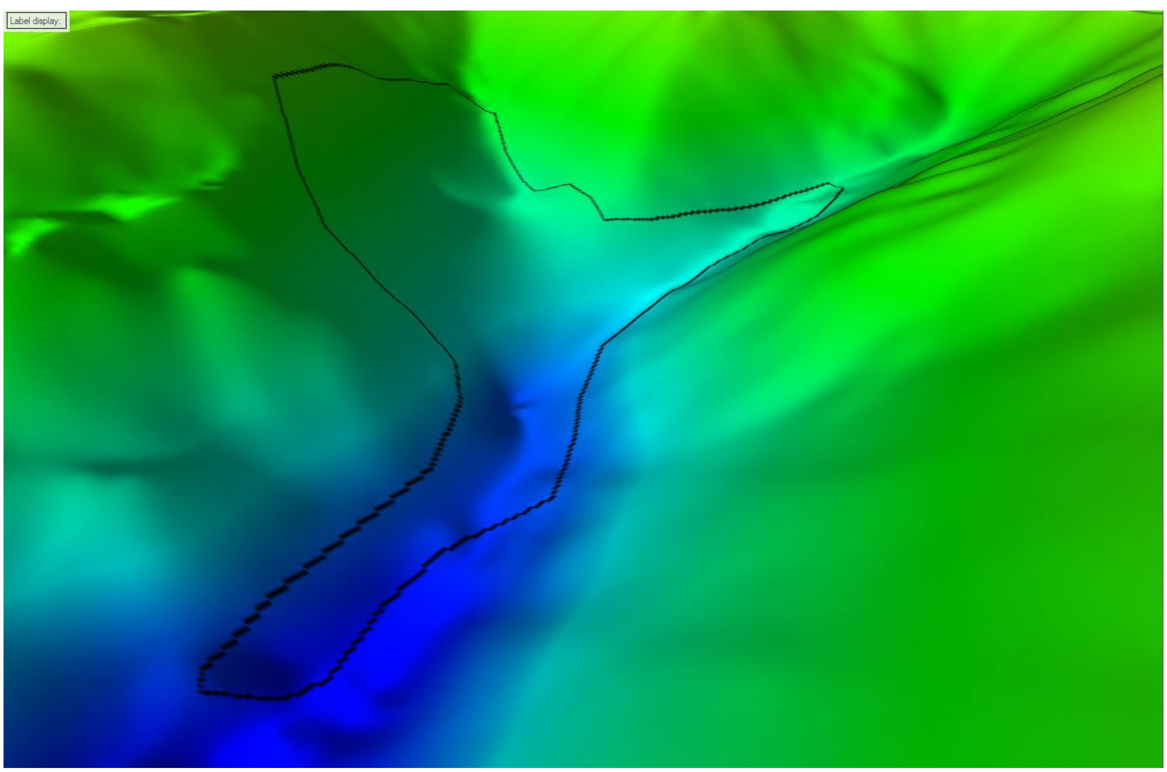
OBJECTID *	Value	Count	AREA	VOLUME	
93	93	51	548.9572	-344.117896	
94	94	25	269.0967	-90.557341	
95	95	5	53.81934	-10.275078	
96	96	1	10.76387	-3.058872	
97	97	2	21.52774	-2.864408	
				69581912.97	CF
				2577107.888	CY

Unique ID: CBC_81222200

Current Surface:



Historical Surface:



Process Documentation:

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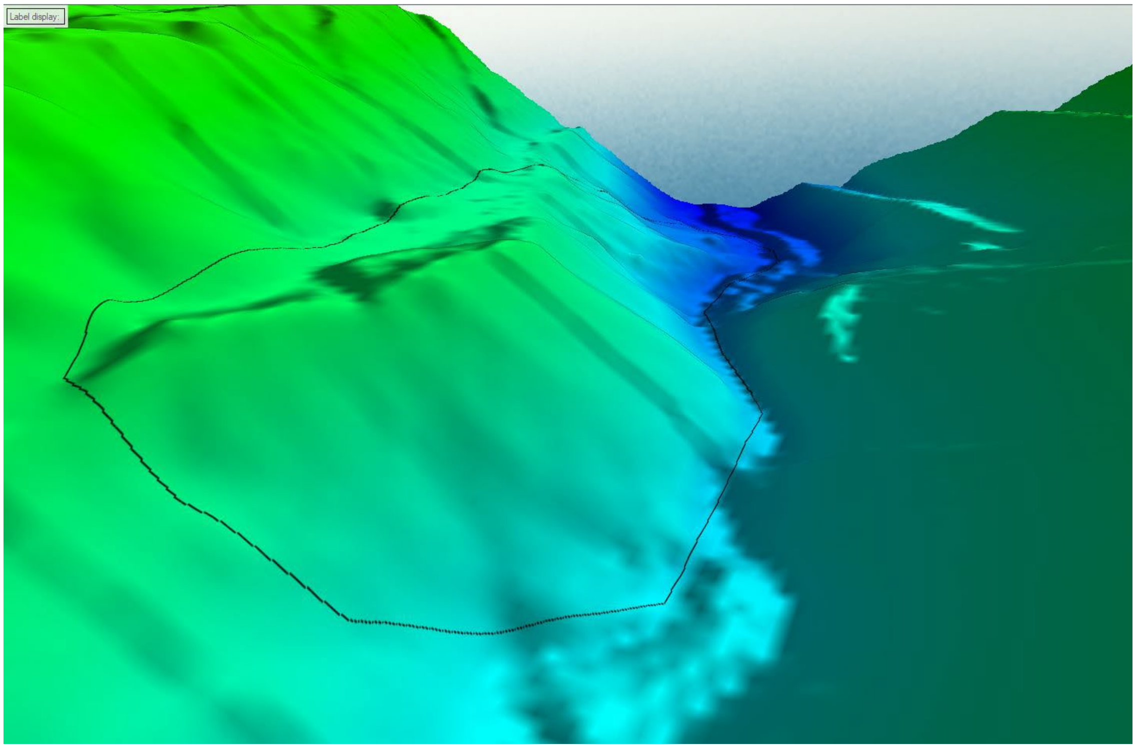
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

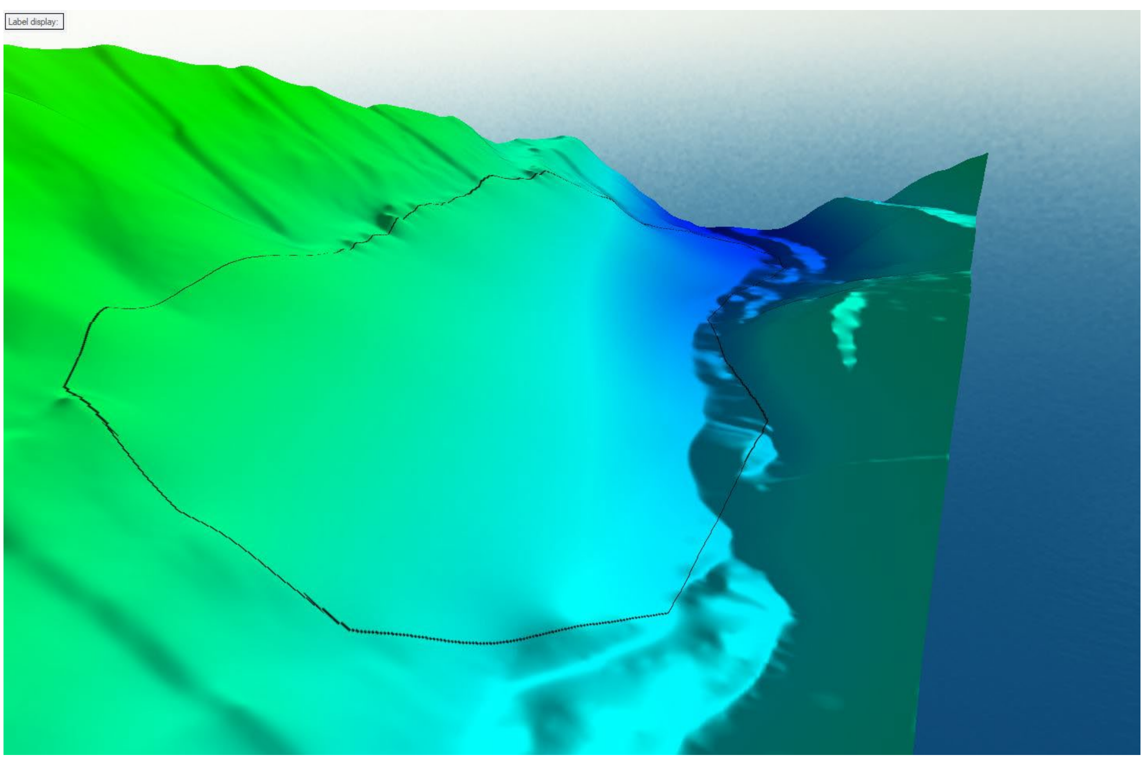
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	178	6290.783318	-9117.661621	
2	2	12	424.097752	211.263701	
3	3	4	141.365917	119.855588	
4	4	1	35.341479	-5.40131	
5	5	8	282.731835	-298.15059	
6	6	1	35.341479	-8.524751	
7	7	3560	125815.6664	1227690.195	
8	8	47	1661.049528	-2725.884158	
9	9	9	318.073314	-365.278693	
10	10	1	35.341479	-2.657514	
11	11	1	35.341479	-37.498552	
12	12	74	2615.269469	-3228.404445	
13	13	1	35.341479	-66.851997	
14	14	5	176.707397	129.363965	
15	15	3	106.024438	-123.237878	
16	16	4	141.365917	54.729249	
17	17	2	70.682959	-64.082316	
18	18	1	35.341479	-9.404837	
19	19	2	70.682959	20.69927	
20	20	22	777.512545	-1511.348682	
21	21	2	70.682959	-23.201474	
22	22	1	35.341479	-2.476319	
23	23	5	176.707397	-162.255009	
24	24	1	35.341479	19.681131	
25	25	10	353.414793	-458.826622	
26	26	7	247.390355	-135.792041	
27	27	12	424.097752	-384.959825	
28	28	19	671.488107	-907.627171	
29	29	1	35.341479	-6.86812	
30	30	27	954.219942	-1608.977793	
31	31	6	212.048876	-124.54075	
32	32	29	1024.9029	-2705.297056	
33	33	8	282.731835	-172.375995	
34	34	6	212.048876	-232.083767	
35	35	1	35.341479	-50.371962	
36	36	3	106.024438	-42.96026	
37	37	1	35.341479	-4.03804	
38	38	19	671.488107	-567.98313	
39	39	3	106.024438	-79.967	
40	40	4	141.365917	-45.08282	
41	41	1	35.341479	-0.120796	
				1202965.594	CF
				44554.28127	CY

Unique ID: CBC_81222257

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

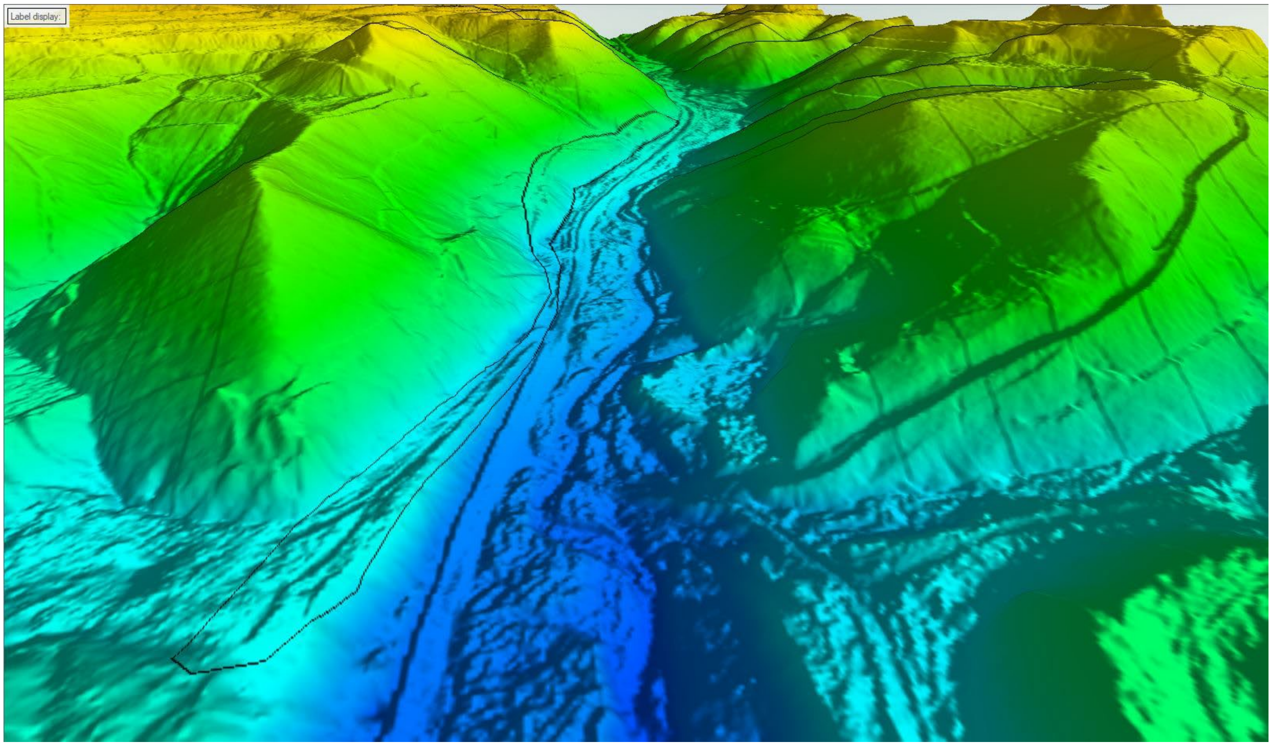
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

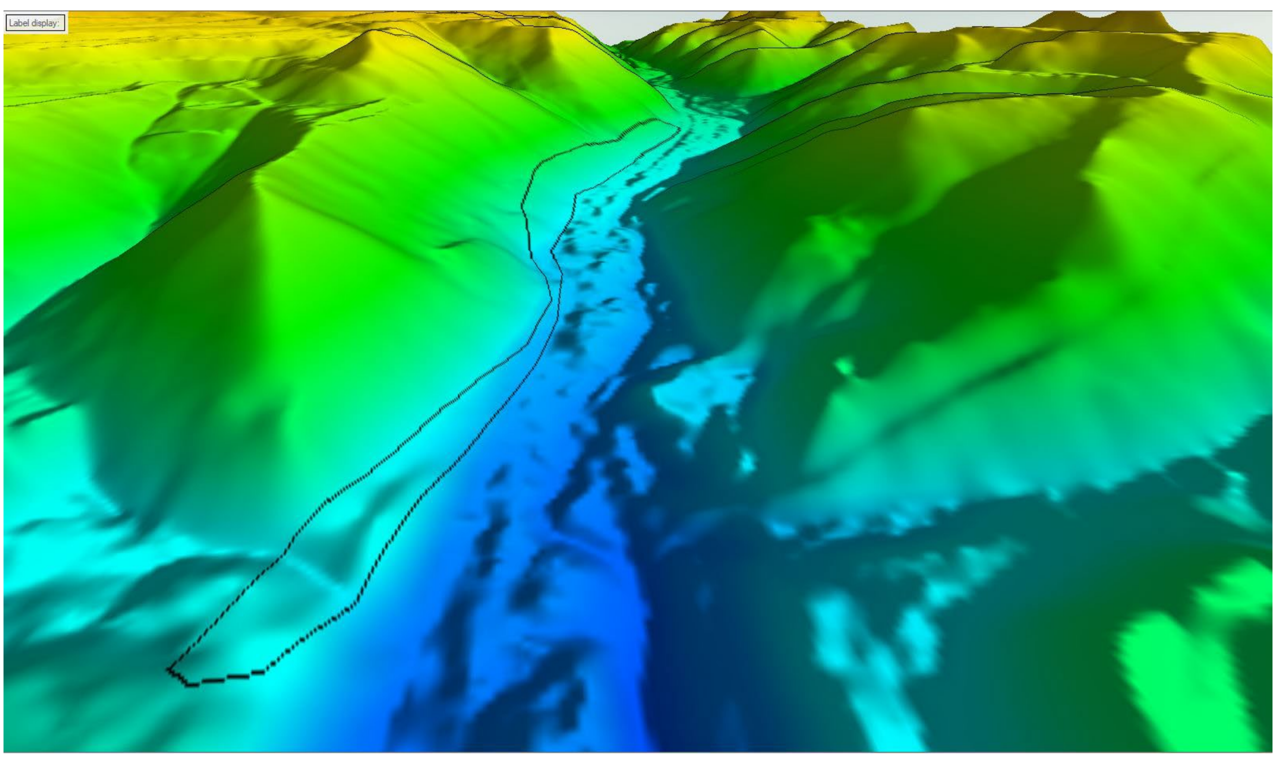
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	1	10.763867	-1.366507	
2	2	3192	34358.26462	319085.6871	
3	3	1	10.763867	-0.677998	
4	4	1	10.763867	-4.877377	
5	5	5	53.819337	14.23532	
6	6	29	312.152153	-104.585057	
7	7	1	10.763867	-1.082694	
8	8	19	204.51348	-116.820547	
9	9	2	21.527735	-2.995803	
10	10	4	43.055469	-6.475139	
11	11	12	129.166408	-38.012535	
12	12	6	64.583204	-30.268121	
13	13	6	64.583204	-12.839906	
14	14	1	10.763867	-2.803966	
15	15	1	10.763867	-1.229856	
16	16	41	441.318562	-180.231709	
17	17	150	1614.580104	-1581.946875	
18	18	38	409.02696	232.829073	
19	19	5	53.819337	-5.820793	
20	20	5	53.819337	7.831134	
21	21	2	21.527735	4.233543	
22	22	1	10.763867	0.407324	
23	23	1	10.763867	0.073581	
24	24	8	86.110939	-16.051197	
25	25	2	21.527735	-4.41224	
26	26	1	10.763867	-2.173271	
27	27	1	10.763867	-1.227228	
28	28	2	21.527735	-2.454456	
29	29	1	10.763867	-0.559742	
30	30	6	64.583204	-14.240575	
31	31	1	10.763867	-0.157674	
32	32	4	43.055469	-1.942016	
33	33	1	10.763867	-0.97495	
				317209.0688	CF
				11748.48403	CY

Unique ID: CBC_82622828

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

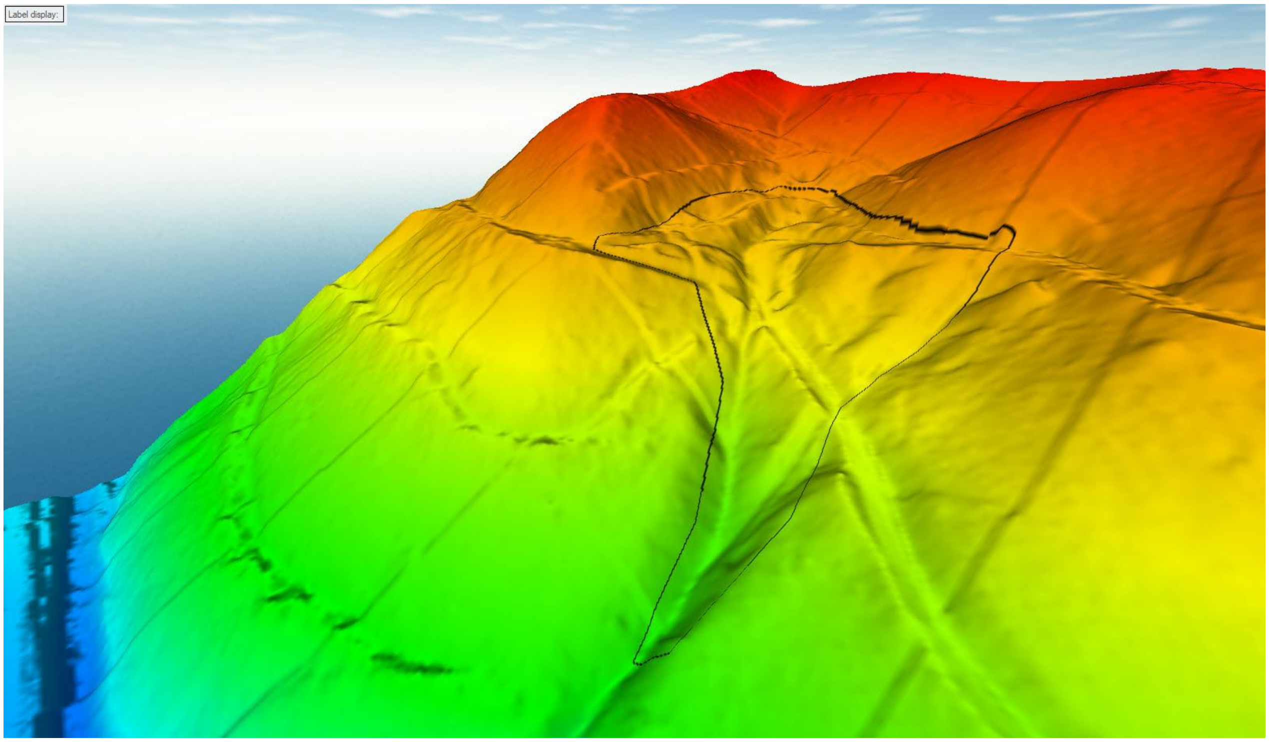
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

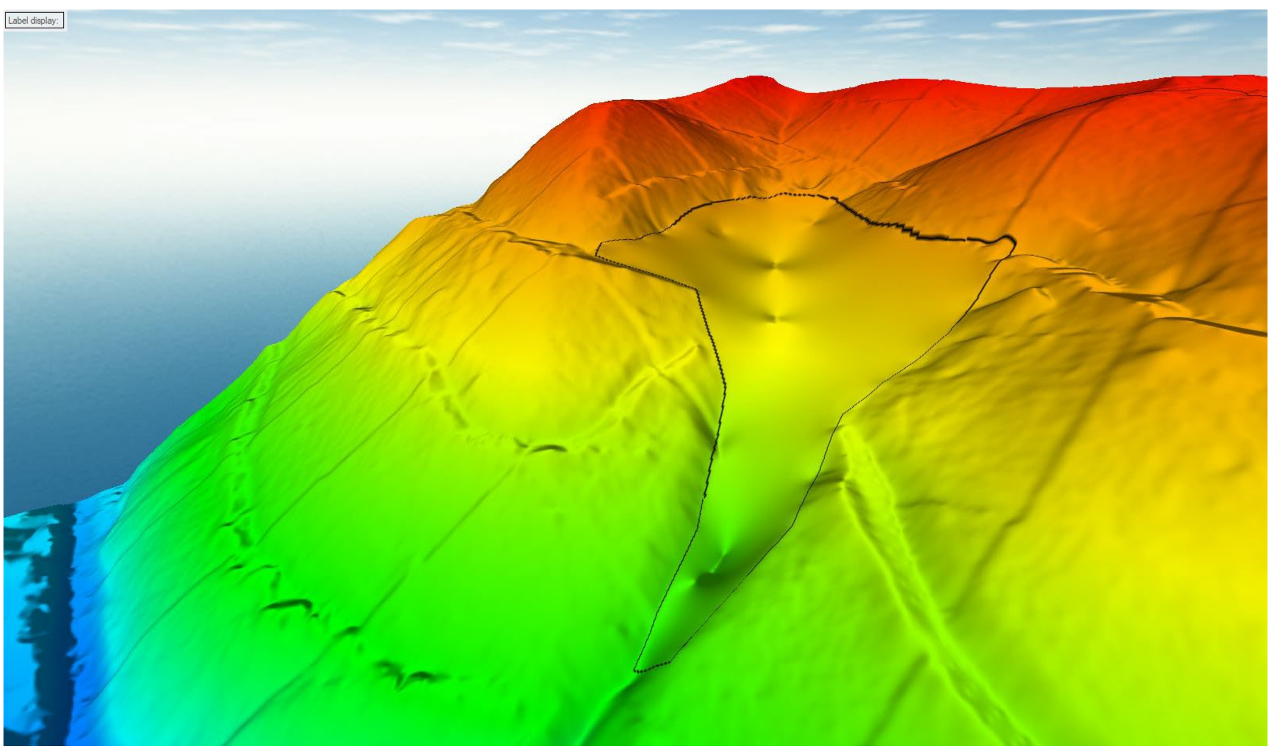
OBJECTID *	Value	Count	AREA	VOLUME
1	1	890	43610	-97572.38648
2	2	583	28567	158725.4033
3	3	2	98	-26.426025
4	4	1	49	4.940674
5	5	1	49	14.762207
6	6	1788	87612	689904.1133
7	7	1	49	-6.214722
8	8	1	49	-3.289795
9	9	10	490	-212.102051
10	10	1	49	-2.781372
11	11	1	49	-5.784058
12	12	21	1029	-910.01709
13	13	6	294	-280.739136
14	14	1	49	-60.71167
15	15	1	49	-34.022461
16	16	2	98	-42.534058
17	17	78	3822	-6603.74292
18	18	3	147	44.304565
19	19	90	4410	-5252.552368
20	20	76	3724	-9482.732178
21	21	1	49	0
22	22	11	539	685.00708
23	23	3	147	-50.710693
24	24	3	147	30.050781
25	25	4	196	51.901001
26	26	523	25627	67872.05212
27	27	5	245	-165.261353
28	28	1	49	-1.668823
29	29	1	49	2.637817
30	30	12	588	-880.020142
31	31	1	49	-30.989868
32	32	4	196	-113.276611
33	33	14	686	-770.380249
34	34	1	49	-32.467285
35	35	2	98	-24.386353
36	36	2	98	-22.412476
37	37	1	49	-0.131592
38	38	1	49	-16.096069
39	39	197	9653	-23561.67871
40	40	52	2548	-1177.620972
41	41	2	98	17.477783
				770009.5131 CF
				28518.87085 CY

Unique ID: CBC_83022145

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

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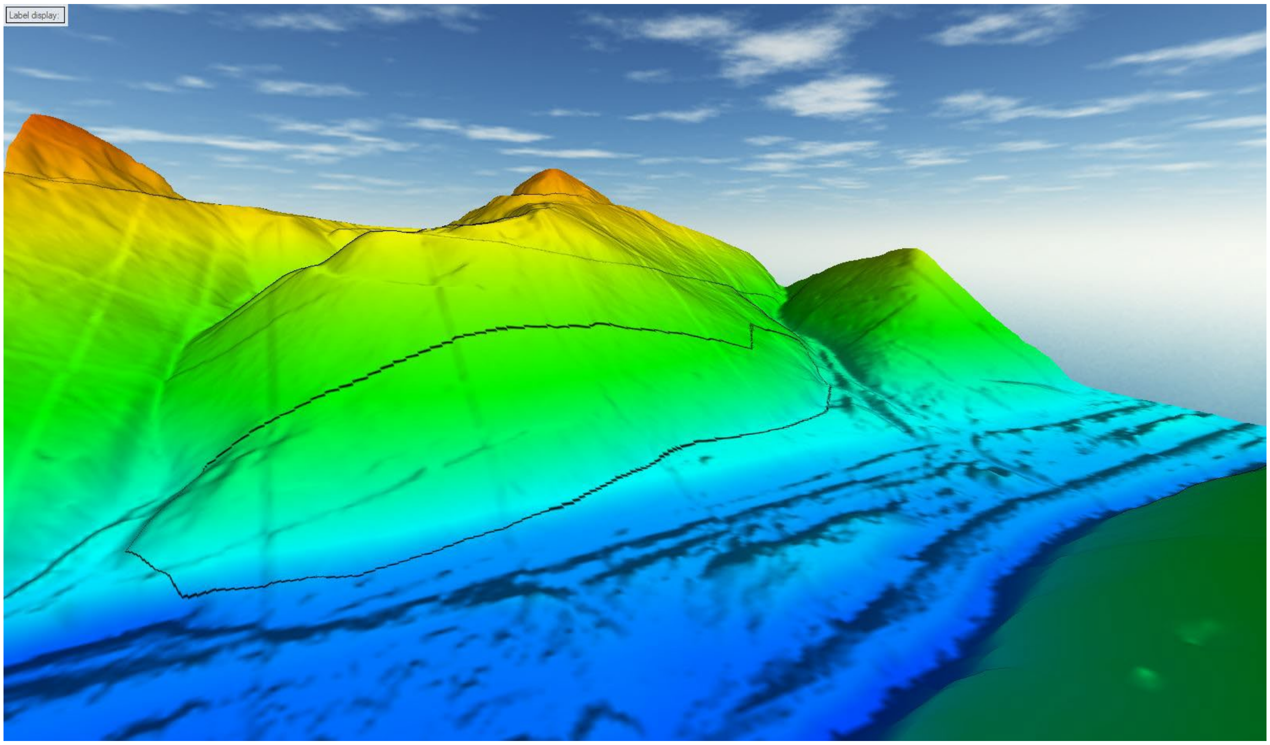
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

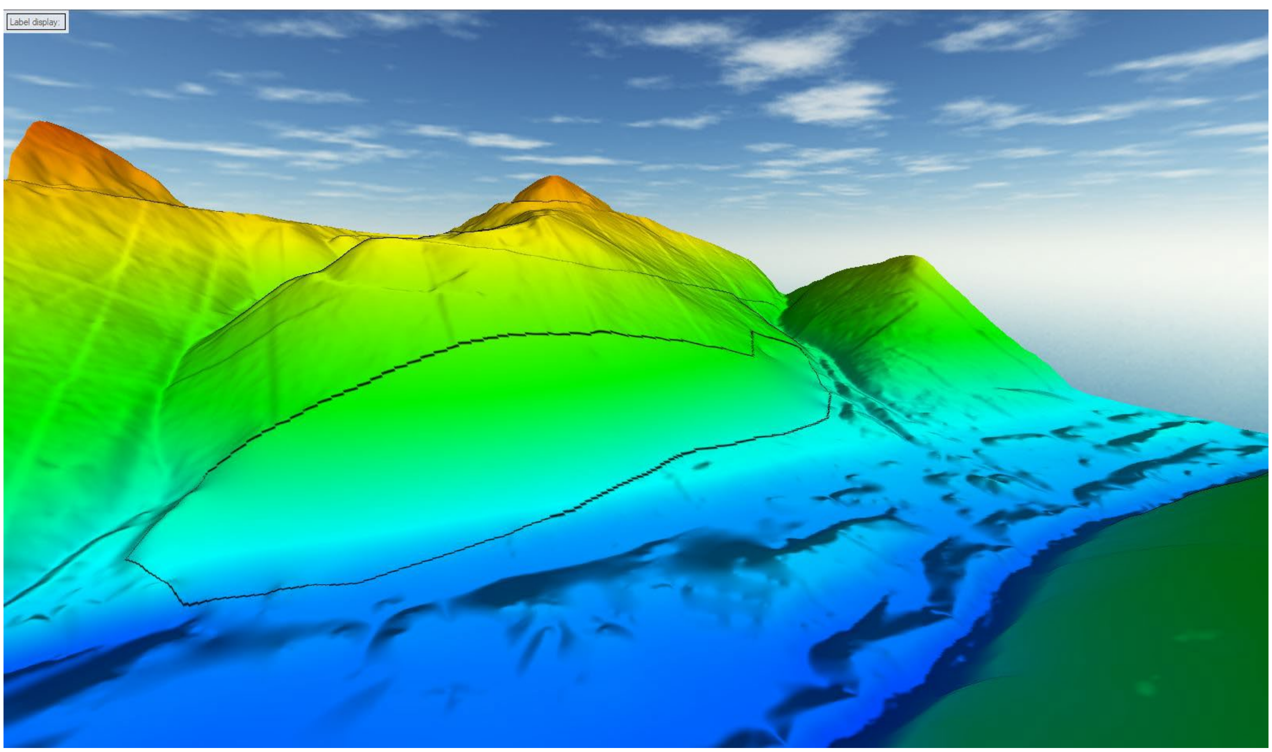
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	5466	58835.299	434674.7013	
2	2	18	193.749612	-71.262005	
3	3	2	21.527735	-3.403127	
4	4	382	4111.79733	-9013.748198	
5	5	12	129.166408	67.716972	
6	6	2	21.527735	-6.843045	
7	7	1	10.763867	-1.514983	
8	8	3	32.291602	-6.715592	
9	9	1	10.763867	0.053872	
10	10	13	139.930276	-75.868709	
11	11	1	10.763867	-2.627897	
12	12	1	10.763867	3.227058	
13	13	2	21.527735	-1.400669	
14	14	1	10.763867	-3.460941	
15	15	1	10.763867	-4.297926	
16	16	89	957.984195	-2115.897503	
17	17	5	53.819337	-30.633399	
18	18	9	96.874806	-29.780646	
19	19	900	9687.48063	-38888.5178	
20	20	1	10.763867	-0.026279	
21	21	3	32.291602	8.65498	
22	22	5	53.819337	37.504036	
23	23	1	10.763867	8.297586	
24	24	2	21.527735	18.422874	
25	25	105	1130.20607	1640.298021	
26	26	30	322.916021	-328.975952	
27	27	1	10.763867	5.171702	
28	28	1	10.763867	3.840672	
29	29	1	10.763867	1.528122	
30	30	1	10.763867	1.144449	
31	31	1	10.763867	0.160302	
32	32	1	10.763867	2.729071	
33	33	38	409.02696	-277.520409	
34	34	18	193.749612	-125.947234	
				385485.0087	CF
				14277.22255	CY

Unique ID: CBC_83022147

Current Surface:



Historical Surface:



Process Documentation:

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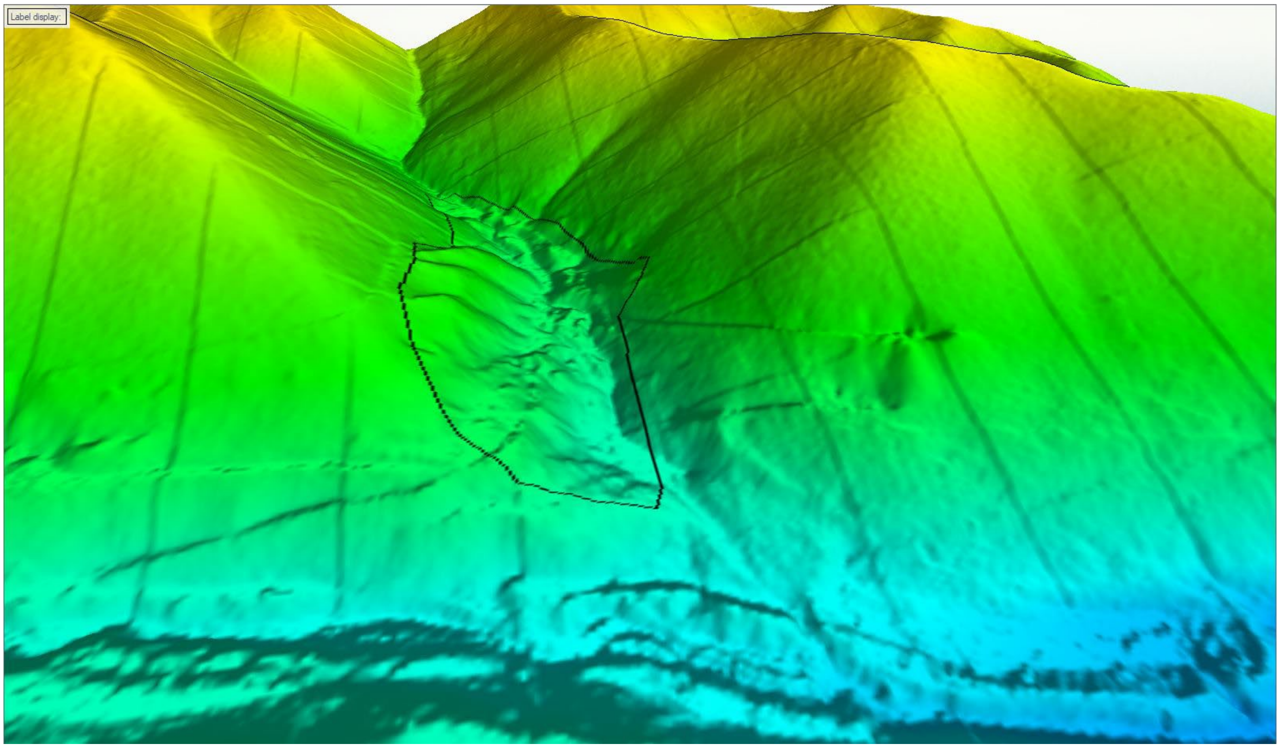
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	5774	62150.57014	306612.4054
2	2	12	129.166408	-75.415397
3	3	5	53.819337	-8.407957
4	4	1	10.763867	-1.691052
5	5	1	10.763867	-4.979865
6	6	1	10.763867	-4.533123
7	7	241	2594.092034	-4069.58279
8	8	2	21.527735	-1.990632
9	9	1	10.763867	-0.886915
10	10	3	32.291602	-12.251257
11	11	4	43.055469	-6.132198
12	12	6	64.583204	-14.343063
13	13	2	21.527735	-11.339377
14	14	12	129.166408	-23.73911
15	15	1	10.763867	-0.248336
16	16	1	10.763867	0.922392
17	17	2	21.527735	-2.51884
18	18	2	21.527735	-1.084008
19	19	5	53.819337	-23.39617
20	20	2	21.527735	-3.269104
21	21	16	172.221878	-146.153137
22	22	8	86.110939	-32.148382
23	23	1	10.763867	-0.172127
24	24	4	43.055469	-5.933792
25	25	14	150.694143	-66.094245
26	26	1	10.763867	-0.536091
27	27	51	548.957235	-216.530854
28	28	9	96.874806	-46.059156
29	29	1	10.763867	-1.253507
30	30	1	10.763867	2.848641
31	31	2	21.527735	-6.180814
32	32	1	10.763867	-2.198236
33	33	1	10.763867	-2.701478
34	34	2	21.527735	-3.844614
35	35	83	893.400991	-459.770343
36	36	2	21.527735	-4.543634
37	37	3	32.291602	5.362224
38	38	1	10.763867	-0.06307
39	39	3	32.291602	-7.393589
40	40	1	10.763867	0.635951
41	41	5	53.819337	-10.70474
42	42	5	53.819337	-19.726311
43	43	1	10.763867	2.302038
44	44	2	21.527735	2.078667
45	45	1	10.763867	-1.570169
46	46	1	10.763867	-0.124825

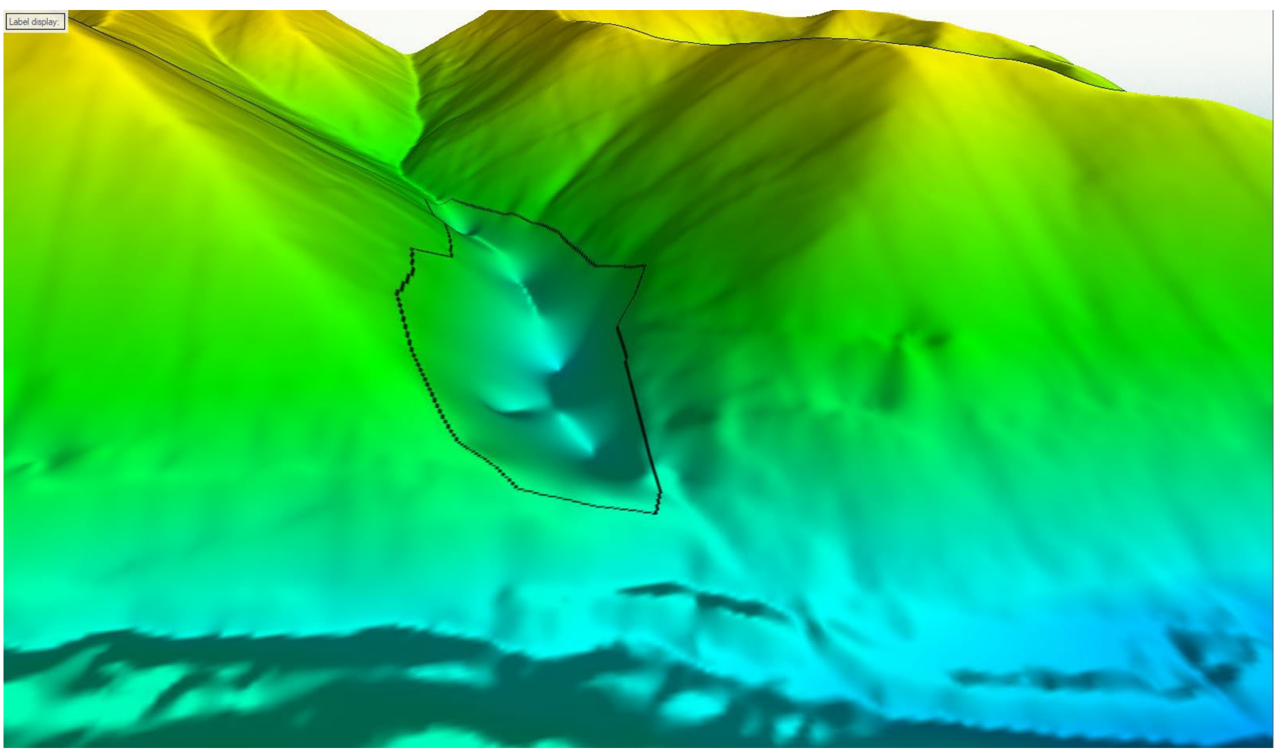
OBJECTID *	Value	Count	AREA	VOLUME	
47	47	2	21.527735	-1.948586	
48	48	33	355.207623	-223.439596	
49	49	2	21.527735	-6.254396	
50	50	1	10.763867	-0.153732	
51	51	1	10.763867	-4.96147	
52	52	2	21.527735	-8.447376	
53	53	1	10.763867	-3.196837	
54	54	5	53.819337	-27.240783	
				301051.4002	CF
				11150.05186	CY

Unique ID: CBC_83022148

Current Surface:



Historical Surface:



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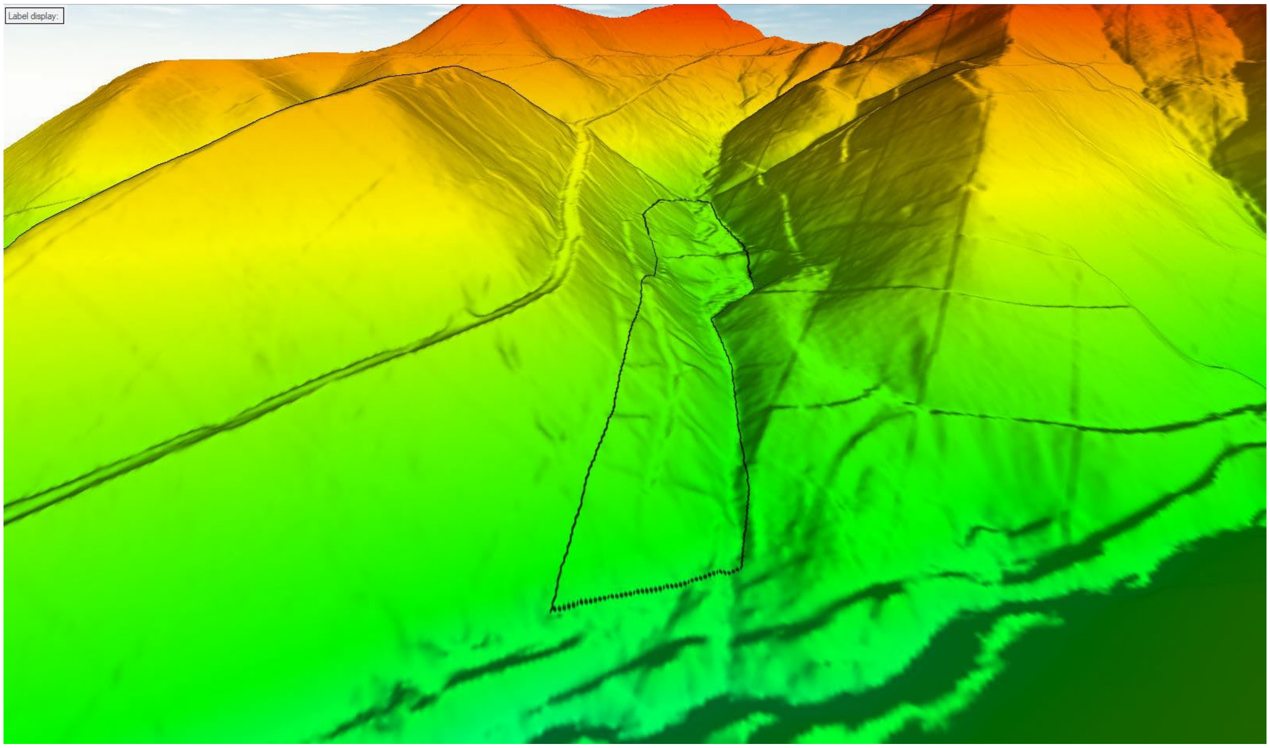
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

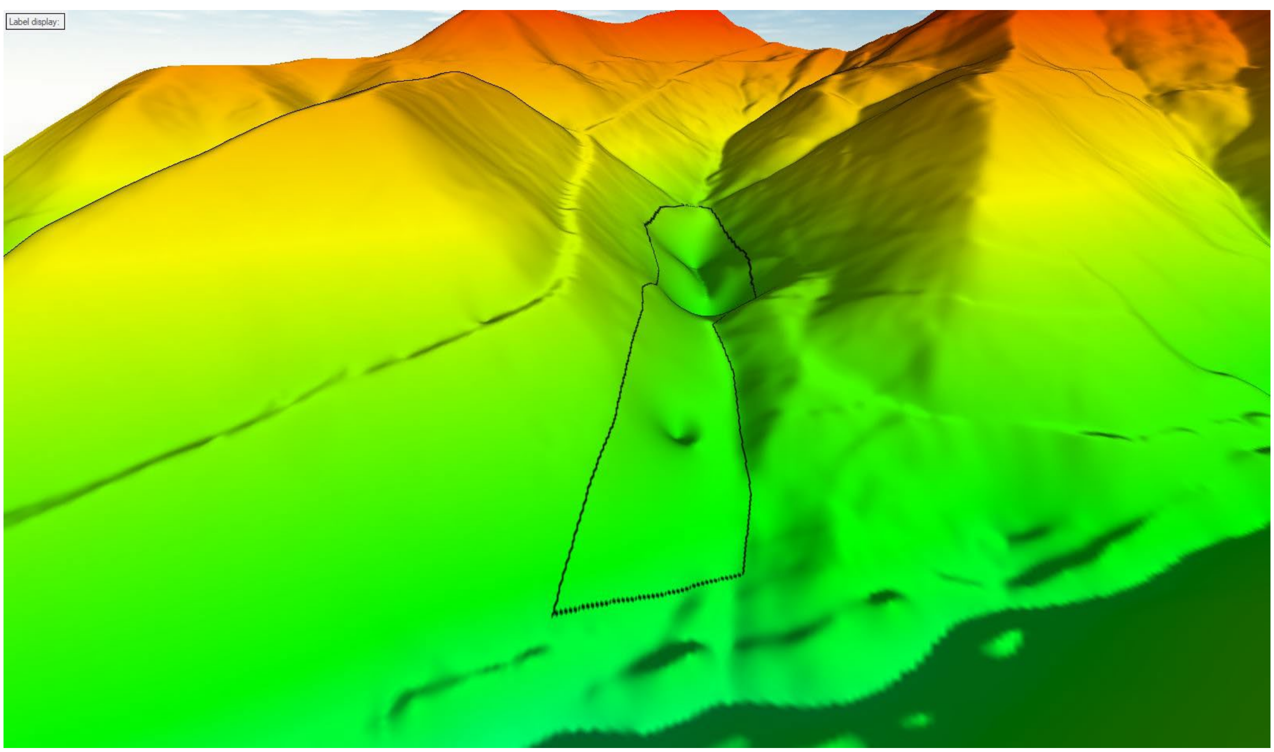
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	1	16	-5.943359	
2	2	6627	106032	2315803.852	
3	3	1	16	-2.001953	
4	4	5	80	-64.595703	
5	5	21	336	-442.185547	
6	6	2	32	12.886719	
7	7	5	80	-74.740234	
8	8	5	80	-108.056641	
9	9	7	112	-72.033203	
10	10	1	16	-7.703125	
11	11	4	64	-70.324219	
12	12	33	528	-576.988281	
13	13	4	64	32.439453	
14	14	34	544	-168.169922	
15	15	67	1072	-670.492188	
16	16	1	16	-0.792969	
17	17	5	80	5.255859	
18	18	1	16	1.689453	
				2313592.096	CF
				85688.59614	CY

Unique ID: CBC_83022149

Current Surface:



Historical Surface:



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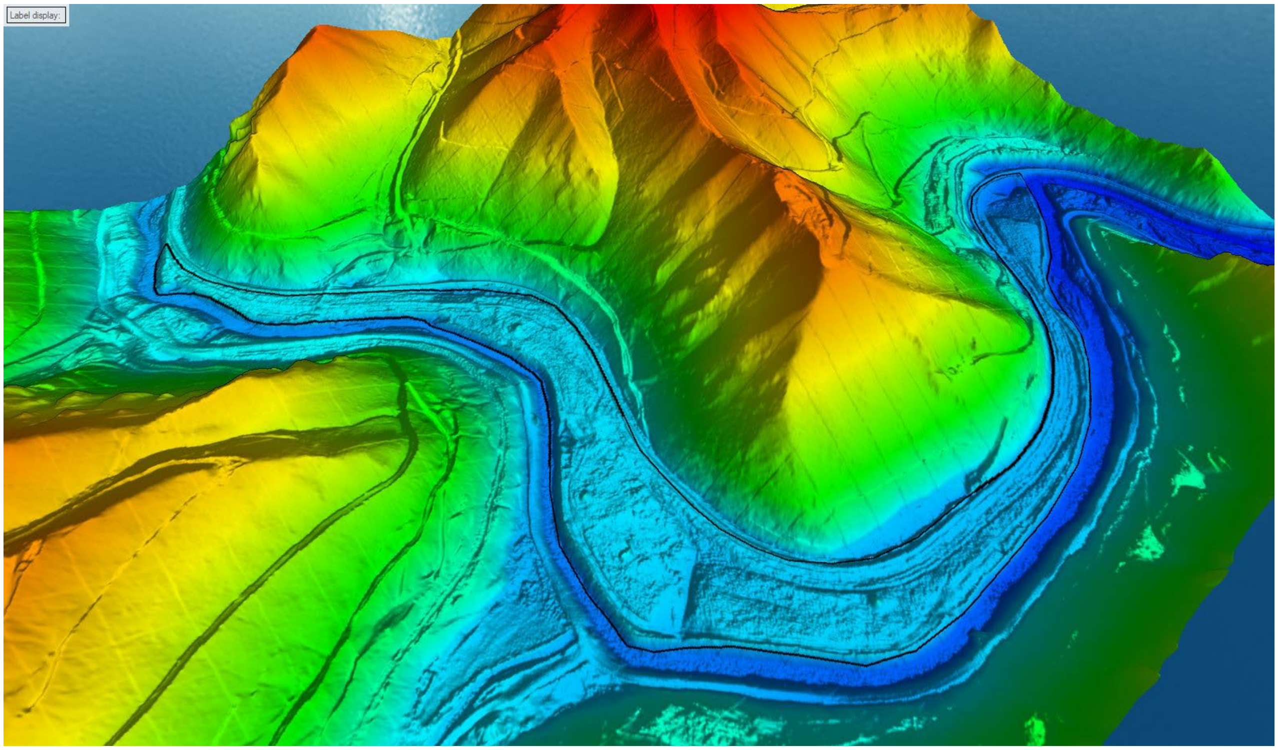
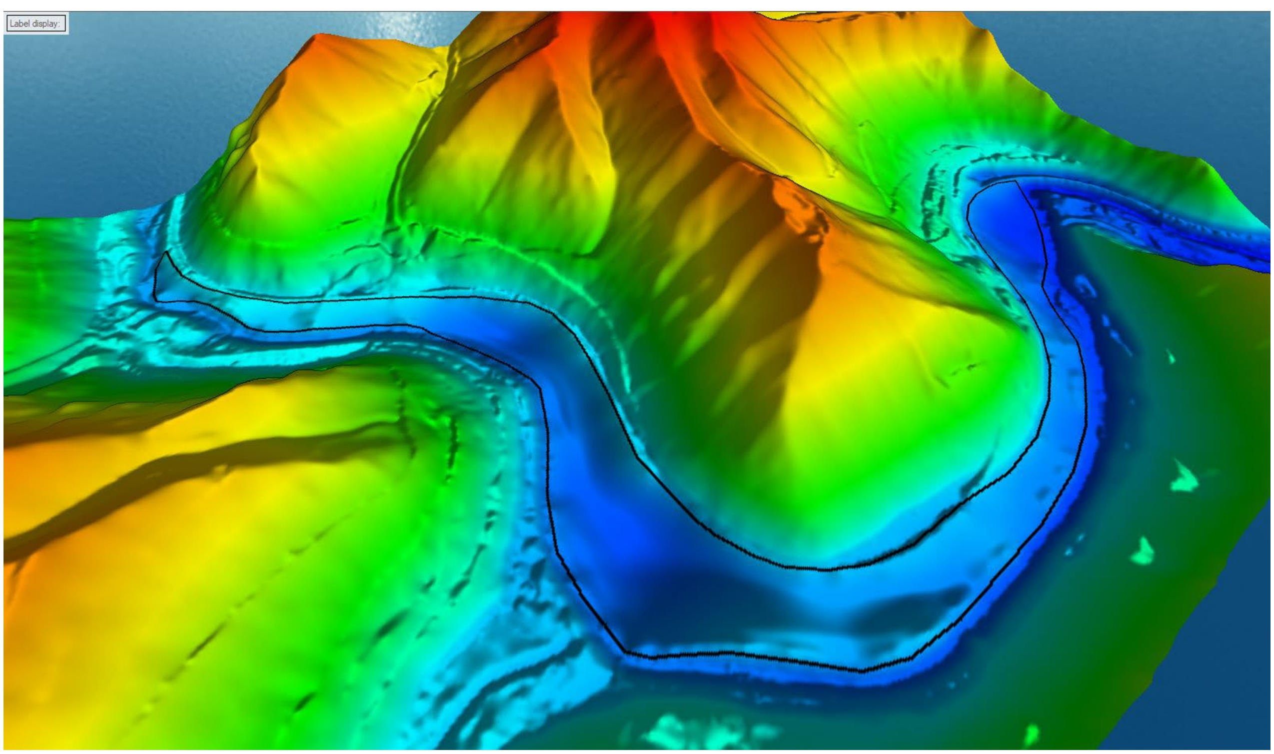
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	151	2416	-5361.306641	
2	2	5549	88784	1461759.73	
3	3	1	16	2.785156	
4	4	1	16	-5.359375	
5	5	4	64	-18.876953	
6	6	1	16	-12.439453	
7	7	1	16	-12.992188	
8	8	9	144	-125.914063	
9	9	38	608	-596.53125	
10	10	7	112	-82.716797	
11	11	1	16	2.183594	
12	12	3	48	-12.248047	
13	13	2	32	-9.105469	
14	14	1	16	-1.660156	
15	15	49	784	-457.003906	
16	16	3	48	-12.121094	
17	17	1	16	-3.976563	
18	18	1	16	-2.363281	
19	19	10	160	-196.419922	
20	20	1	16	-3.042969	
21	21	25	400	-293.564453	
22	22	103	1648	-1770.662109	
23	23	5	80	40.441406	
24	24	1	16	1.613281	
25	25	1	16	-6.132813	
26	26	1	16	-1.970703	
				1452820.346	CF
				53808.16095	CY

Unique ID: CBC_90222553

Current Surface:



Historical Surface:



Process Documentation:

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3: Trim contours inside the gob pile boundary.

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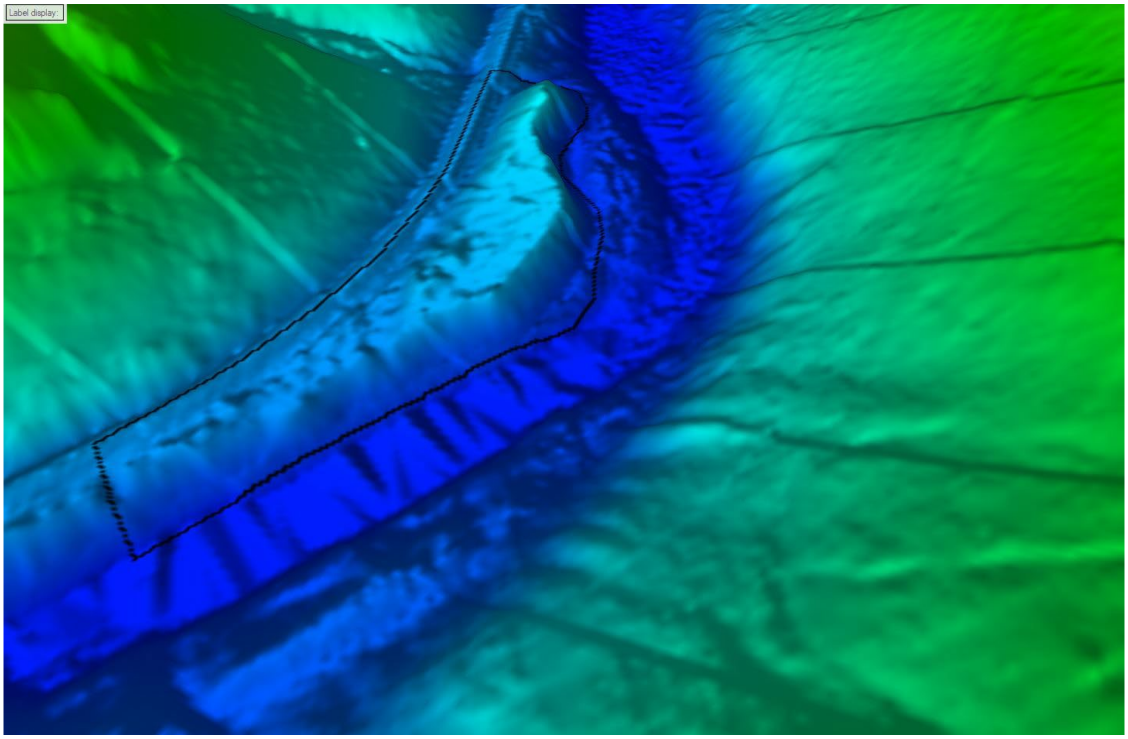
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	25912	1269688	13949752.47
2	2	22	1078	-1168.433472
3	3	27	1323	-420.262329
4	4	4	196	55.471924
5	5	7	343	-21.198242
6	6	1	49	-12.519165
7	7	38	1862	-1939.22644
8	8	5	245	-102.9646
9	9	1	49	-8.637207
10	10	1	49	-7.369141
11	11	2	98	-10.688843
12	12	1	49	-0.86731
13	13	1	49	-0.783569
14	14	1	49	-3.792236
15	15	1	49	-12.668701
16	16	1	49	-1.411621
17	17	1	49	-13.452271
18	18	3	147	-18.219482
19	19	1	49	-1.776489
20	20	2	98	-14.199951
21	21	1	49	-22.621826
22	22	4	196	-40.171387
23	23	2	98	-1.597046
24	24	1	49	-2.799316
25	25	1	49	-9.157593
26	26	226	11074	-21459.26648
27	27	1	49	-15.701294
28	28	7	343	-26.007324
29	29	5	245	-33.651611
30	30	16	784	-369.420044
31	31	1	49	-5.233765
32	32	4	196	-11.998779
33	33	26	1274	-499.827515
34	34	1	49	8.631226
35	35	3	147	36.851685
36	36	5	245	-128.325928
37	37	1	49	-22.633789
38	38	1	49	-5.490967
39	39	2	98	-20.89917
40	40	3	147	-43.78418
41	41	10	490	-175.029053
42	42	5	245	-95.996216
43	43	21	1029	-676.310059
44	44	1	49	-10.401733
45	45	1	49	-6.148926
46	46	79	3871	-4550.468262

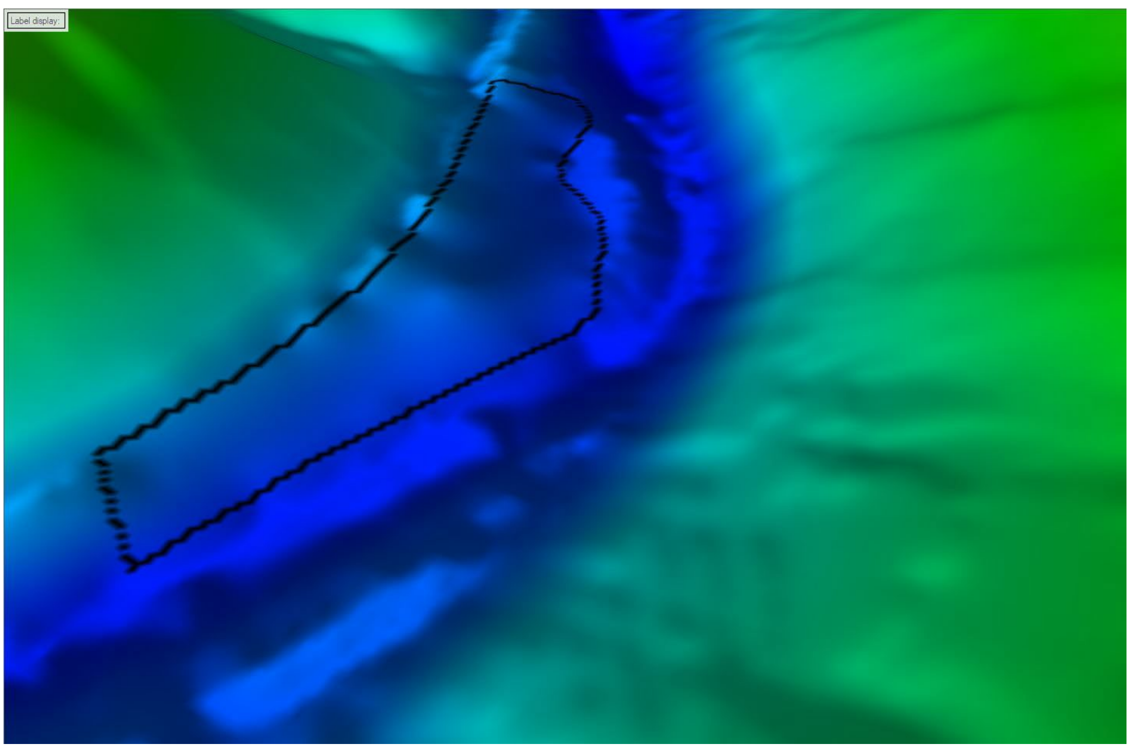
OBJECTID *	Value	Count	AREA	VOLUME	
47	47	1	49	0.107666	
48	48	1	49	-2.613892	
49	49	1	49	14.570801	
50	50	1	49	8.385986	
51	51	3	147	-154.369141	
52	52	10	490	-580.630859	
53	53	1	49	9.031982	
54	54	1	49	-23.686523	
55	55	1	49	-5.347412	
56	56	3	147	-30.122559	
57	57	13	637	-266.527222	
58	58	2	98	-9.510498	
59	59	17	833	-545.274536	
60	60	1	49	-15.533813	
61	61	1	49	4.611694	
62	62	1	49	-0.687866	
63	63	1	49	-4.396362	
64	64	235	11515	-9852.810181	
65	65	1	49	1.471436	
66	66	1	49	-80.707642	
67	67	1	49	-4.504028	
68	68	1	49	-0.275146	
69	69	1	49	-9.546387	
70	70	1	49	-1.680786	
71	71	1	49	-23.393433	
72	72	10	490	-582.53894	
				13905706.03	CF
				515026.1494	CY

Unique ID: CBC_517221258

Current Surface:



Historical Surface:



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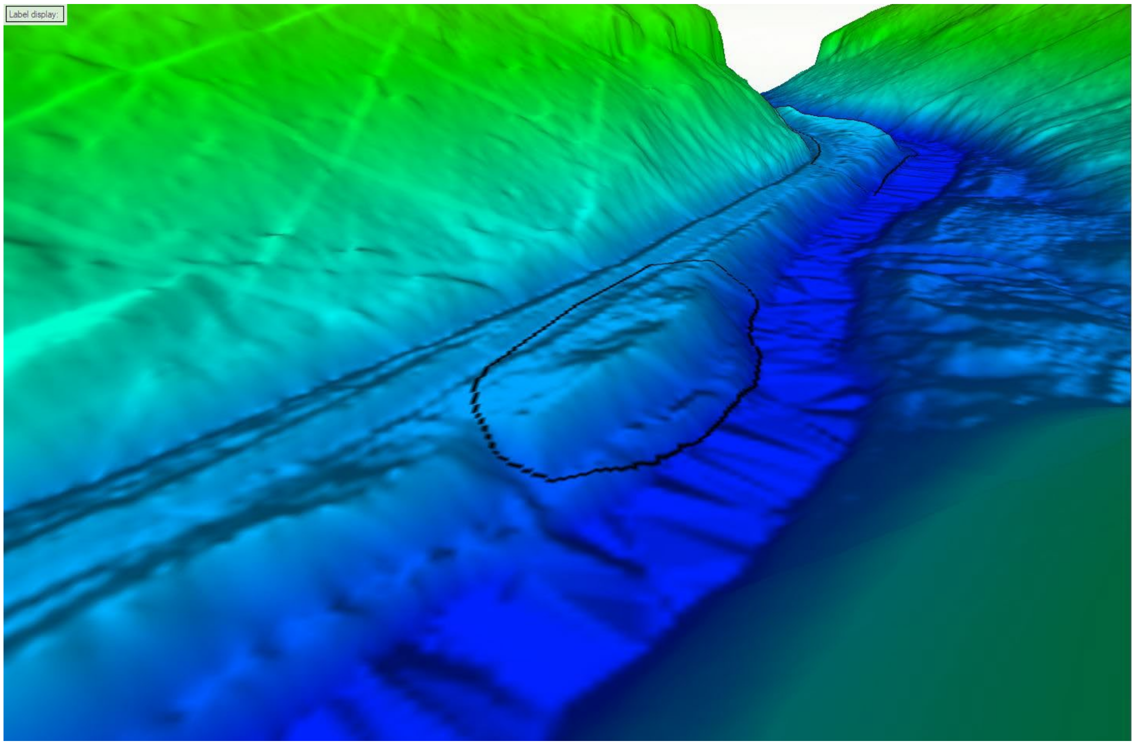
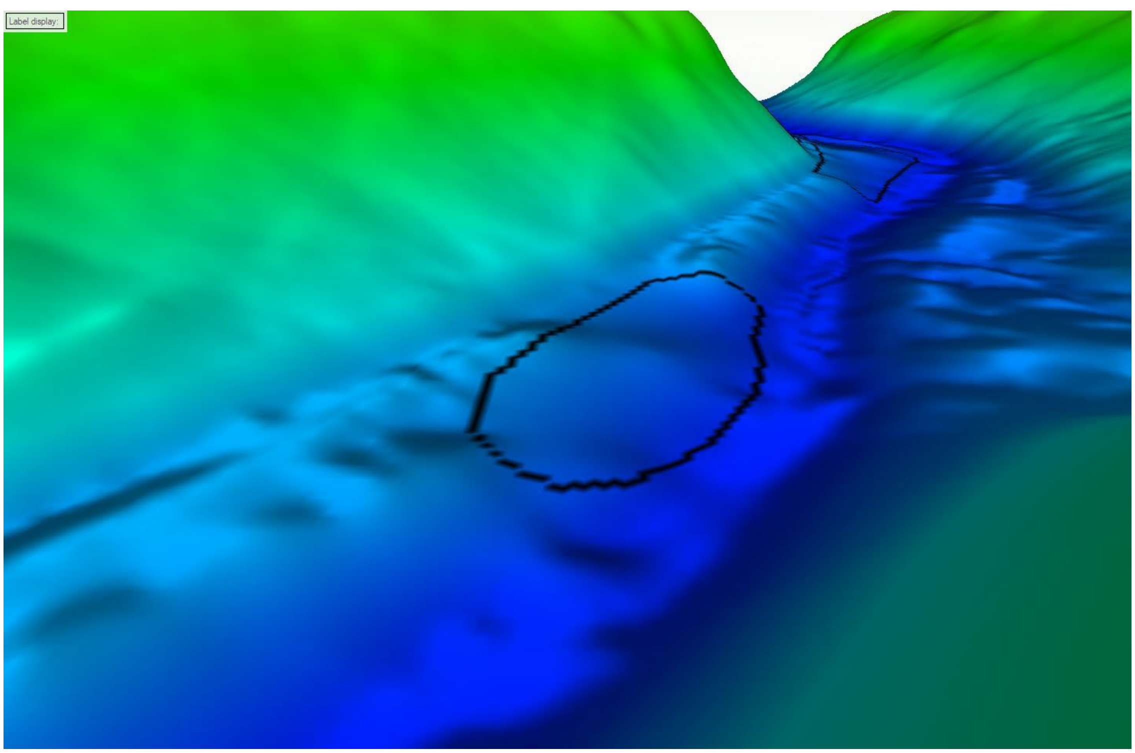
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	14	350	-541.78772	
2	2	1527	38175	331523.941	
3	3	4	100	-29.40979	
4	4	7	175	-165.170288	
5	5	25	625	-268.545532	
6	6	2	50	21.71936	
7	7	3	75	-14.538574	
8	8	1	25	-10.910034	
9	9	1	25	-11.999512	
10	10	1	25	-10.845947	
11	11	21	525	-744.631958	
12	12	2	50	-55.688477	
				329692.1326	CF
				12210.81972	CY

Unique ID: CBC_517221259

Current Surface:



Historical Surface:



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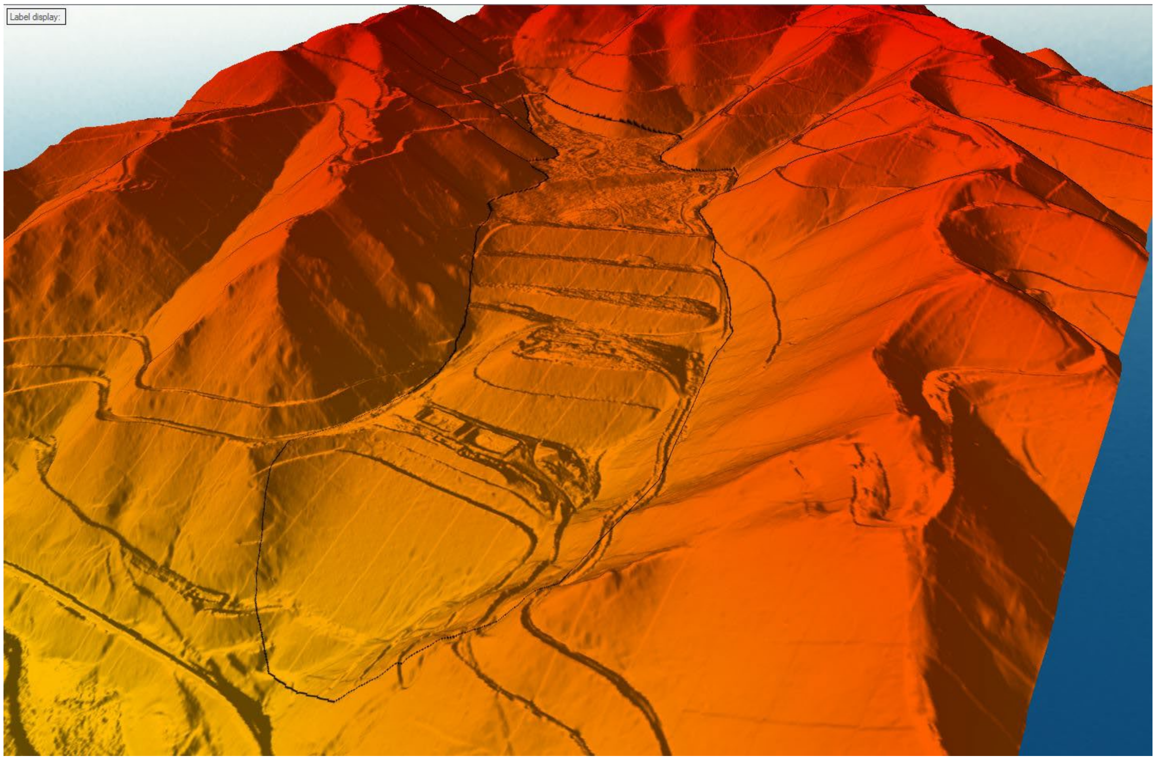
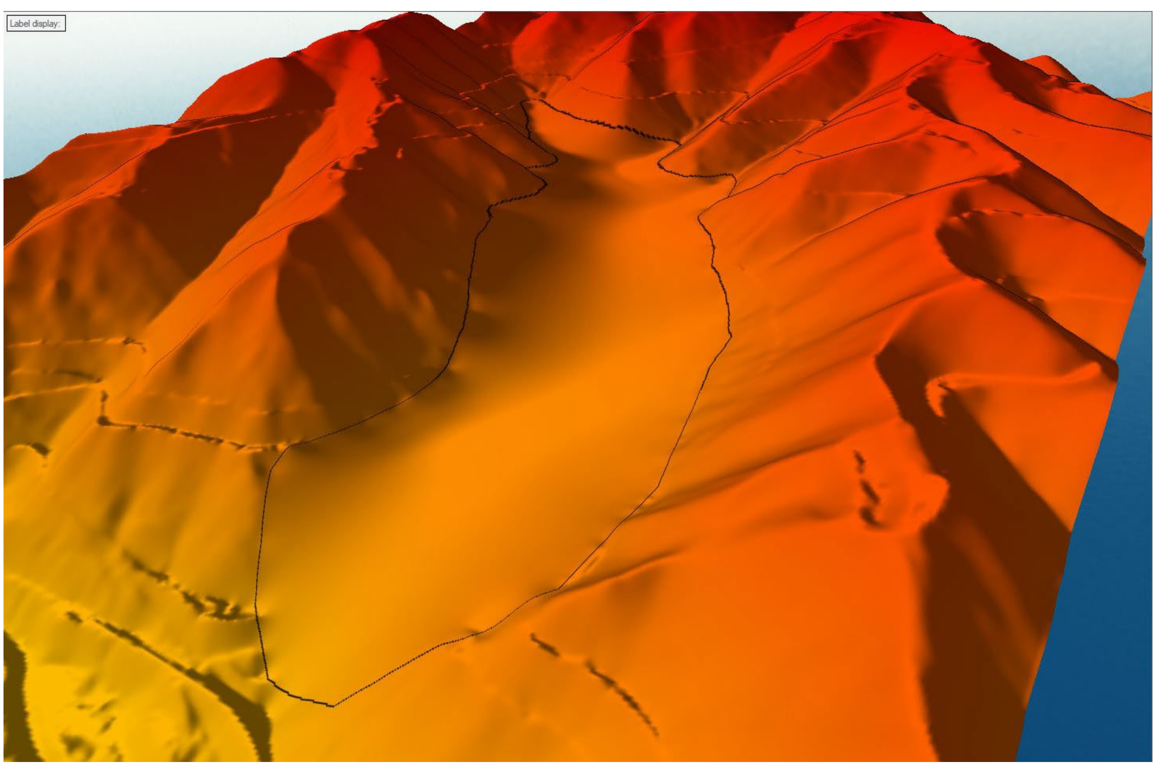
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	626	15650	92784.14307	
2	2	2	50	-64.801025	
3	3	16	400	-625.952148	
4	4	3	75	-12.585449	
5	5	1	25	-22.695923	
6	6	2	50	-19.824219	
7	7	1	25	-5.59082	
8	8	1	25	-3.521729	
				92029.17175	CF
				3408.487843	CY

Unique ID: CBC_722221202

Current Surface:



Historical Surface:



Process Documentation:

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OBJECTID *	Value	Count	AREA	VOLUME
1	1	1	49	-16.712158
2	2	37528	1838872	46180971.6
3	3	2222	108878	-1002329.4
4	4	6	294	-421.57227
5	5	4	196	-40.554199
6	6	50	2450	3957.64722
7	7	2	98	-20.229248
8	8	46	2254	-2645.7249
9	9	1	49	45.674316
10	10	41	2009	5386.63843
11	11	5	245	-58.965088
12	12	1	49	43.293701
13	13	1	49	44.334473
14	14	1	49	87.747803
15	15	1	49	-14.104248
16	16	3	147	-72.088379
17	17	2	98	-49.729736
18	18	2	98	-28.280273
19	19	2	98	-11.819336
20	20	1	49	-24.177002
21	21	1	49	-37.958252
22	22	1	49	-28.974121
23	23	1	49	-34.369385
24	24	33	1617	-1716.7466
25	25	1	49	7.273438
26	26	2	98	-32.718506
27	27	3	147	-63.427246
28	28	1	49	-18.171631
29	29	2	98	-15.958496
30	30	3	147	-266.4375
31	31	2	98	-168.82031
32	32	1	49	-9.163574
33	33	2	98	-103.31152
34	34	1	49	-25.349365
35	35	1	49	-40.901123
36	36	1	49	-8.948242
37	37	3	147	-35.326416
38	38	1	49	-11.568115
39	39	1	49	-21.293945
40	40	1	49	-38.221436
41	41	3	147	-46.368164
42	42	97	4753	-10387.318
43	43	1	49	-0.62207
44	44	2	98	-43.054443
45	45	3	147	-105.65625
46	46	1	49	-25.026367

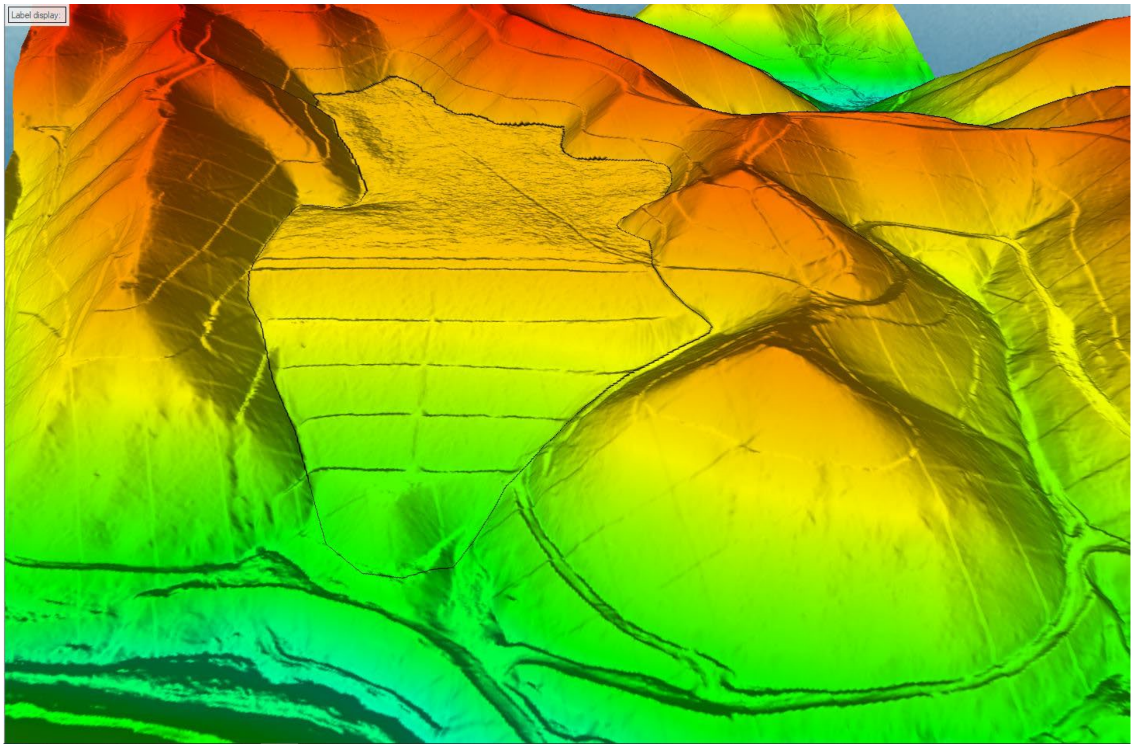
OBJECTID *	Value	Count	AREA	VOLUME
47	47	2	98	-28.531494
48	48	3	147	-80.414551
49	49	2	98	-58.594238
50	50	1	49	-20.779541
51	51	5	245	-287.80322
52	52	176	8624	-41475.892
53	53	1	49	82.567871
54	54	6	294	-165.97315
55	55	5	245	1328.23975
56	56	1	49	-41.056641
57	57	3	147	-137.05884
58	58	312	15288	-159841.06
59	59	9079	444871	-10457759
60	60	1	49	-4.306641
61	61	7	343	182.081177
62	62	1	49	39.154541
63	63	1	49	-45.847778
64	64	41	2009	-4550.4922
65	65	46	2254	-1456.0154
66	66	3	147	161.989502
67	67	8	392	364.401611
68	68	110	5390	8377.1936
69	69	6	294	-490.45459
70	70	1	49	-10.204346
71	71	1	49	-12.369629
72	72	2	98	-131.54395
73	73	5	245	-175.16065
74	74	4	196	-502.59692
75	75	3	147	-416.78711
76	76	2	98	-293.84448
77	77	4	196	265.827393
78	78	2	98	-106.13477
79	79	3	147	-184.79077
80	80	11	539	-1119.6428
81	81	3	147	-184.88648
82	82	4	196	-172.94751
83	83	12	588	551.806274
84	84	4	196	-336.25293
85	85	6	294	232.409058
86	86	2	98	-136.35303
87	87	88	4312	-13684.949
88	88	2	98	79.278076
89	89	19	931	949.847534
90	90	14	686	-395.31372
91	91	1	49	-73.631592
92	92	5	245	193.709106

OBJECTID *	Value	Count	AREA	VOLUME
93	93	1	49	-32.311768
94	94	16	784	-1172.8657
95	95	15	735	1818.0304
96	96	200	9800	-46751.658
97	97	1	49	-52.361572
98	98	1	49	-50.291992
99	99	1	49	-1.770508
100	100	8	392	304.323975
101	101	1	49	-38.161621
102	102	1	49	-54.04834
103	103	21	1029	-1274.646
104	104	2	98	54.443115
105	105	37	1813	2654.5116
106	106	1	49	-7.536621
107	107	3	147	129.916992
108	108	2	98	-12.41748
109	109	13	637	-1057.699
110	110	18	882	1242.62134
111	111	2	98	-126.02905
112	112	5	245	-247.08154

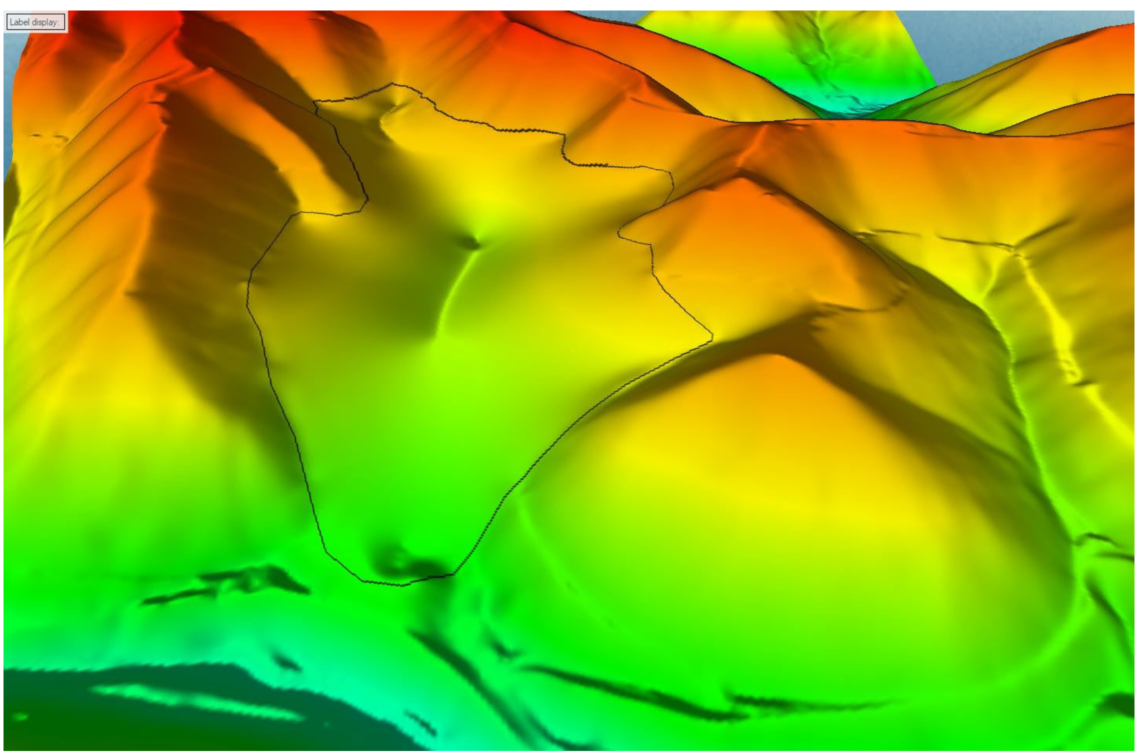
34455277.6	CF
1276121.39	CY

Unique ID: CBC_722221215

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

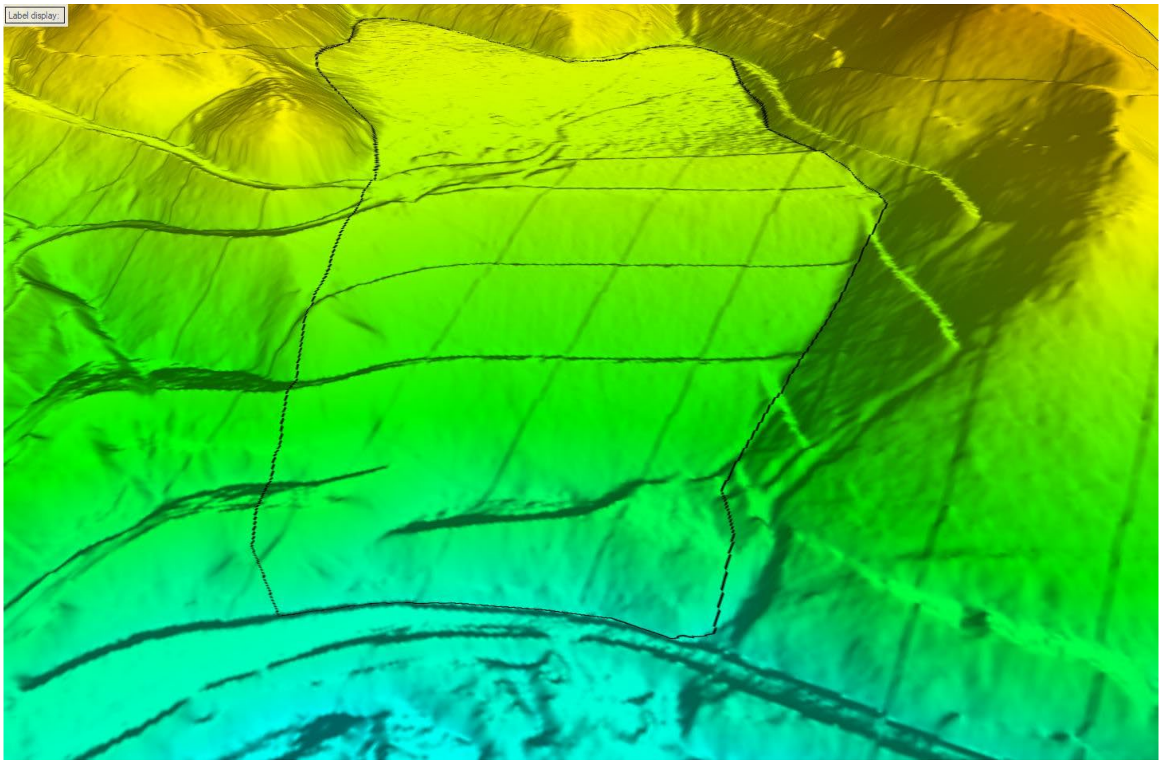
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	25	1225	-2080.173218
2	2	14128	692272	17989849.84
3	3	3	147	-138.231201
4	4	3	147	-135.126831
5	5	1	49	-28.806641
6	6	1	49	-0.502441
7	7	1	49	-12.040649
8	8	1	49	-0.293091
9	9	1	49	-7.716064
10	10	2	98	-8.768799
11	11	4	196	-100.356689
12	12	2	98	-9.139648
13	13	70	3430	-5862.055664
14	14	2	98	-48.718872
15	15	8	392	-608.396729
16	16	1	49	-13.398438
17	17	1	49	-29.560303
18	18	1	49	-26.408081
19	19	9	441	-615.275391
20	20	15	735	-936.317505
21	21	9	441	-628.488403
22	22	1	49	27.957275
23	23	42	2058	-2432.504272
24	24	1	49	-19.302124
25	25	3	147	-202.818848
26	26	1	49	3.702515
27	27	115	5635	-8049.775269
28	28	1	49	-6.609497
29	29	6	294	-222.826782
30	30	4	196	-39.8125
31	31	1	49	-4.498047
32	32	6	294	-50.9021
33	33	66	3234	-4552.155029
34	34	64	3136	-4359.480713
35	35	1	49	31.390625
36	36	1	49	7.751953
37	37	311	15239	-16727.05798
38	38	8	392	-255.575195
39	39	4	196	-67.452759
40	40	4	196	-77.268311
41	41	8	392	-160.619751
42	42	2	98	-13.94873
43	43	4	196	-35.38623
44	44	17	833	-257.33374
45	45	1	49	-0.251221
46	46	1	49	-4.294678

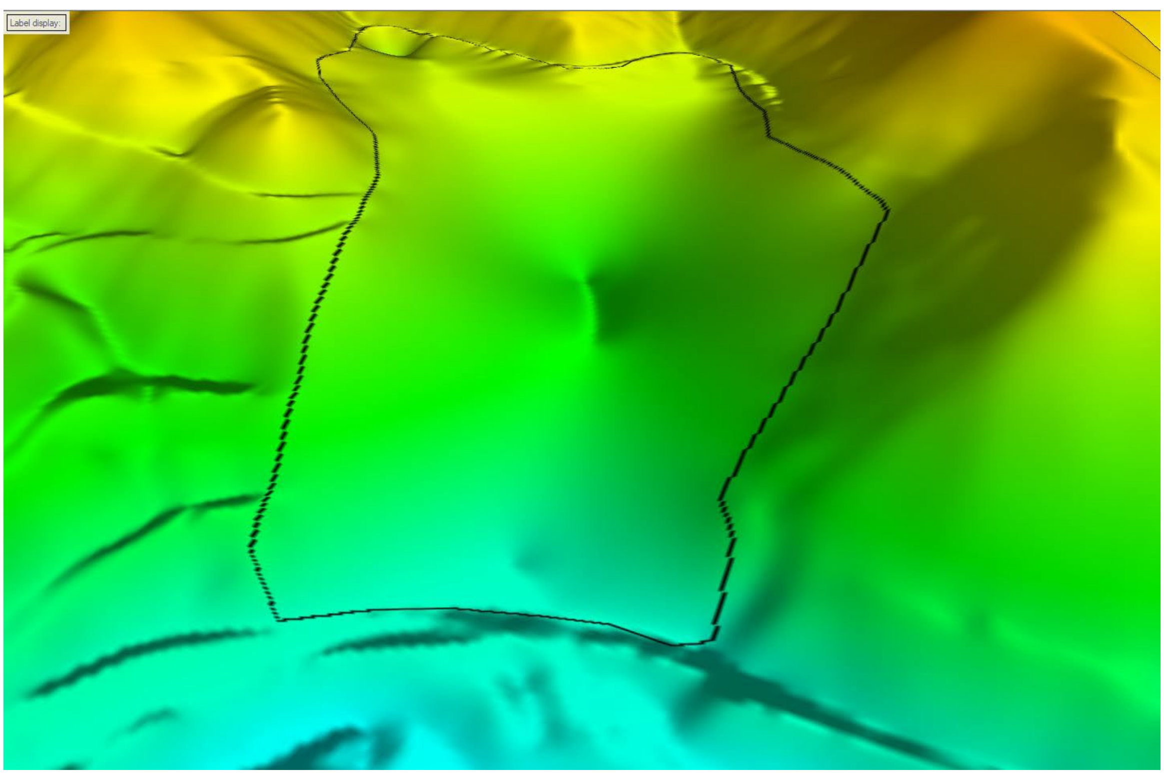
OBJECTID *	Value	Count	AREA	VOLUME	
47	47	8	392	-68.439697	
48	48	1	49	31.737549	
49	49	1	49	4.629639	
				17941058.92	CF
				664483.6637	CY

Unique ID: CBC_722221235

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

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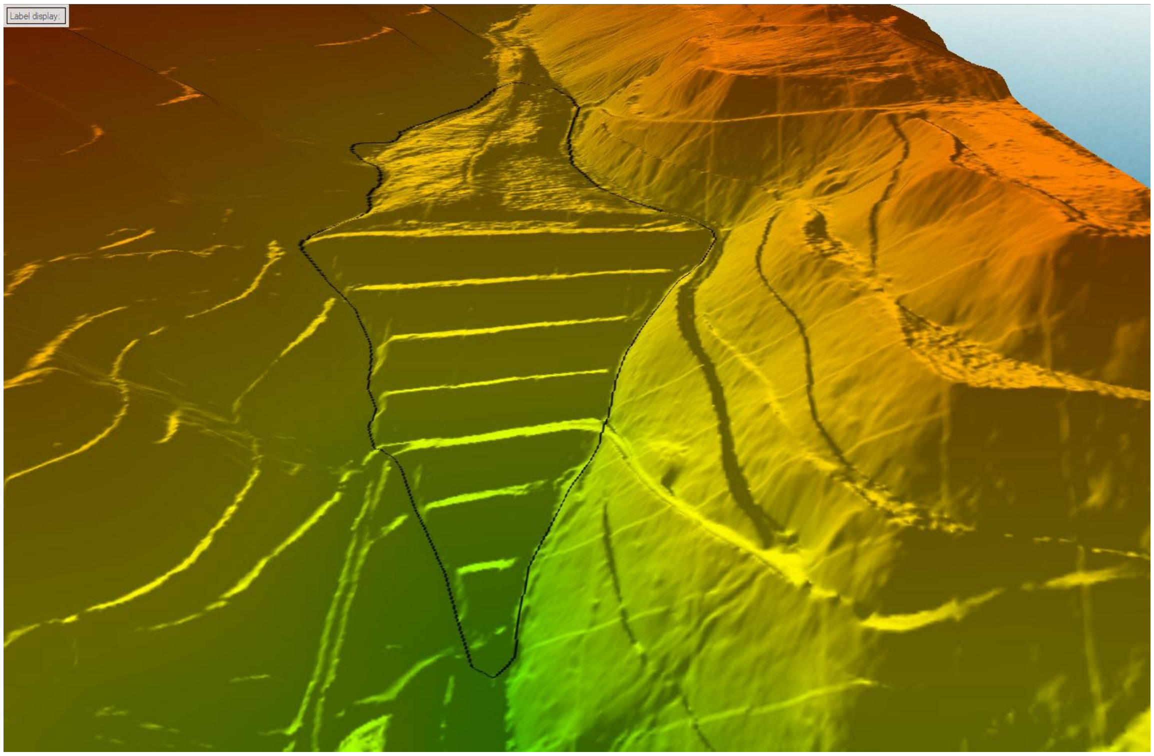
OBJECTID *	Value	Count	AREA	VOLUME
1	1	14	686	-759.775146
2	2	26353	1291297	61850649.55
3	3	1	49	-3.923828
4	4	1	49	-78.273193
5	5	1	49	-15.073242
6	6	2	98	-136.329102
7	7	136	6664	-20063.83118
8	8	6	294	-331.802734
9	9	1	49	-53.665527
10	10	1	49	-8.302246
11	11	19	931	-2165.624146
12	12	63	3087	-1019.788574
13	13	7	343	-426.14209
14	14	1	49	1.327881
15	15	8	392	-217.820313
16	16	6	294	-369.784912
17	17	1	49	-50.519287
18	18	25	1225	-1925.786133
19	19	1	49	-13.661621
20	20	6	294	-316.908936
21	21	3	147	-108.323975
22	22	20	980	-639.099487
23	23	4	196	-148.208252
24	24	5	245	-325.713623
25	25	1	49	-13.86499
26	26	3	147	-20.81543
27	27	26	1274	-1847.477051
28	28	34	1666	-1522.923828
29	29	1	49	0.448608
30	30	16	784	-1162.206787
31	31	137	6713	-12723.53308
32	32	1	49	-2.560059
33	33	5	245	-421.440674
34	34	4	196	-251.759033
35	35	24	1176	-2371.224365
36	36	4	196	-435.963623
37	37	64	3136	-5424.536865
38	38	9	441	-101.301758
39	39	2	98	41.032715
40	40	12	588	-836.612793
41	41	3	147	-18.638184
42	42	33	1617	-2509.323975
43	43	39	1911	-4560.768311
44	44	63	3087	-5194.119629
45	45	1	49	14.199951
46	46	2	98	46.164795

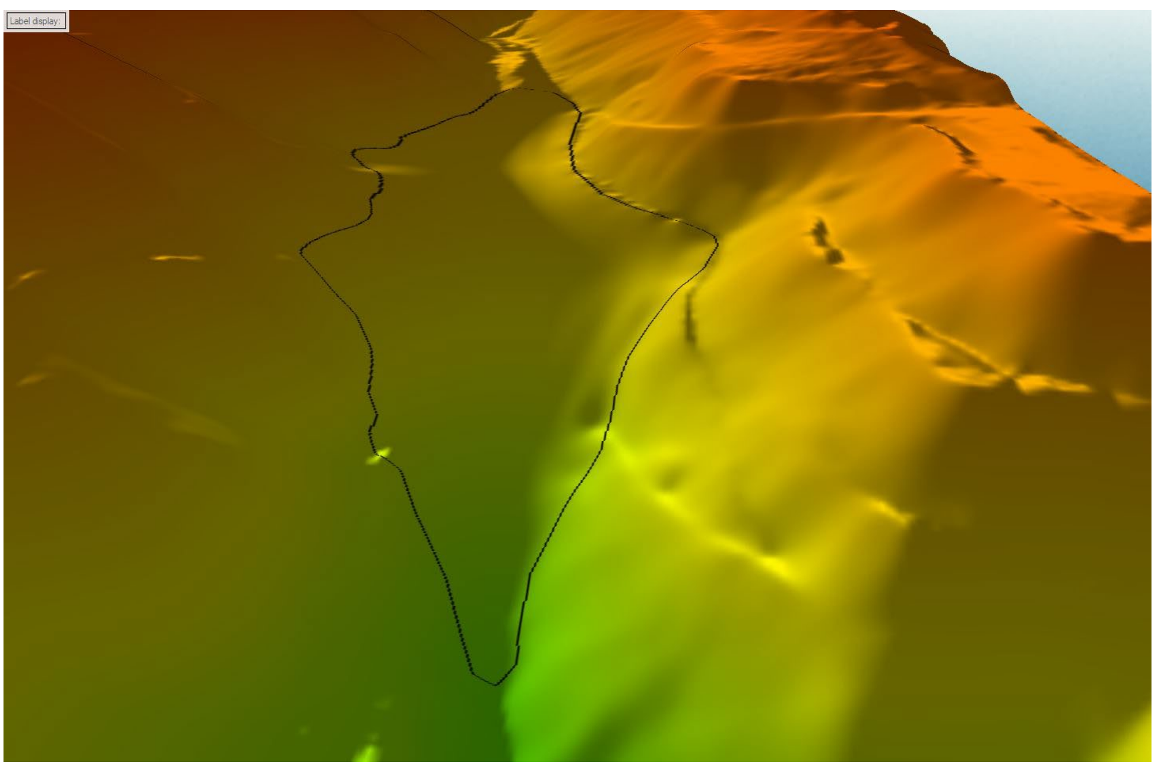
OBJECTID *	Value	Count	AREA	VOLUME	
47	47	1	49	-38.831543	
48	48	11	539	-574.099121	
49	49	1	49	-33.615723	
50	50	10	490	-450.235352	
51	51	75	3675	-5905.337402	
				61775153.18	CF
				2287968.636	CY

Unique ID: CBC_722221252

Current Surface:



Historical Surface:



Process Documentation:

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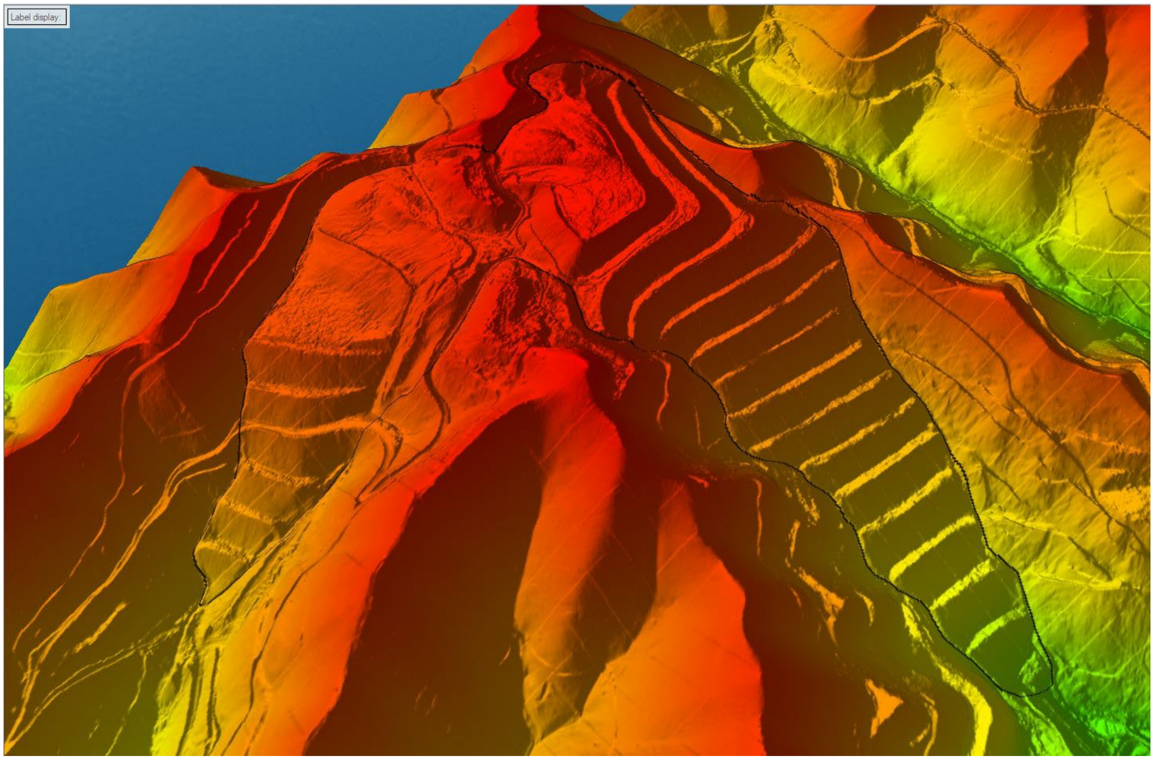
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	1	64	18.148438
2	2	54	3456	-1947.609375
3	3	4	256	-23.015625
4	4	8824	564736	12941707.31
5	5	8	512	-159.304688
6	6	122	7808	-8078.226562
7	7	1	64	-17.210938
8	8	17	1088	-559.546875
9	9	3	192	-126.257813
10	10	12	768	-669.328125
11	11	42	2688	-2061.515625
12	12	1	64	23.945313
13	13	22	1408	-984.601563
14	14	1	64	-1.5
15	15	4	256	-360.757813
16	16	2	128	-3.054688
17	17	1	64	-132.921875
18	18	4	256	-192.742188
19	19	1	64	-6.195313
20	20	3	192	-50.695313
21	21	3	192	-56.960938
22	22	1	64	-22.1875
23	23	1	64	-2.03125
24	24	2	128	-96.257813
25	25	5	320	-192.5625
26	26	67	4288	-10068.48438
27	27	30	1920	-4952.257813
28	28	20	1280	-3085.640625
29	29	11	704	-1495.640625
30	30	6	384	-931.28125
31	31	81	5184	-16994.59375
32	32	1	64	-175.054688
33	33	1	64	10.773438
34	34	1	64	-33.210938
35	35	1	64	48.53125
36	36	13	832	-3118.382813
37	37	2	128	-245.625
38	38	27	1728	-4218.90625
39	39	16	1024	-2605.195313
40	40	10	640	-1288.6875

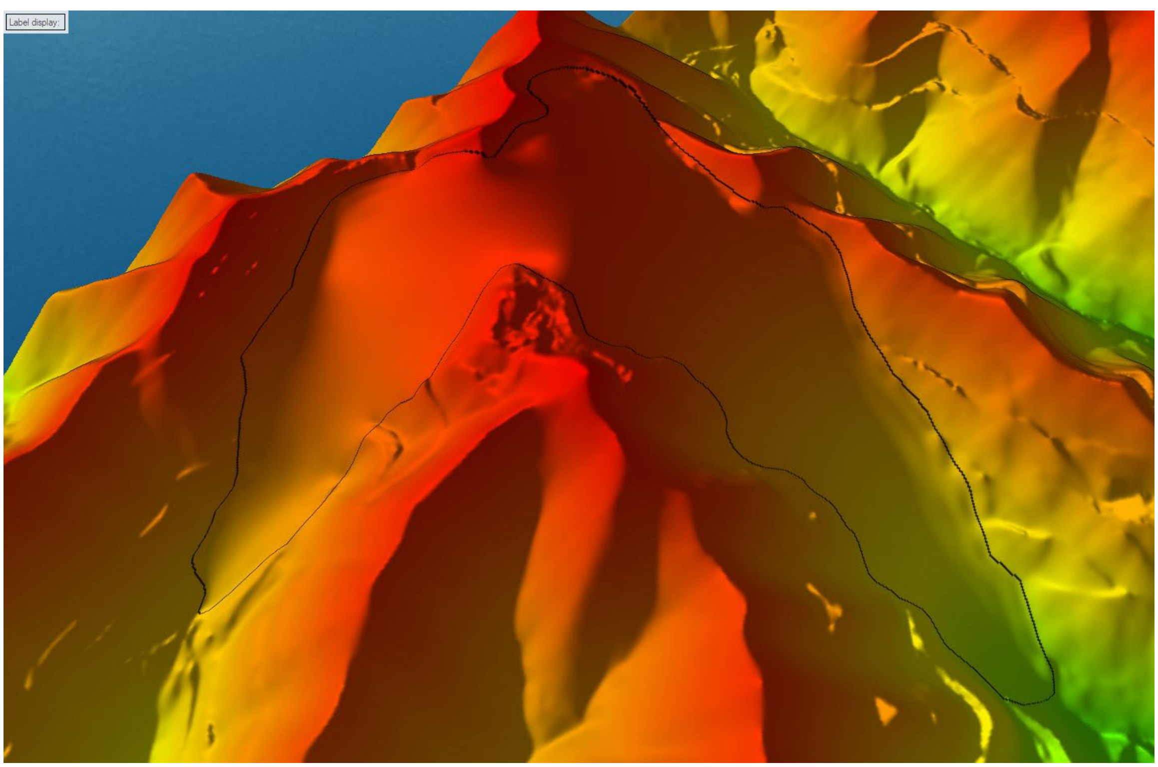
12876851.27 CF
476920.4172 CY

Unique ID: CBC_722221259

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

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OBJECTID *	Value	Count	AREA	VOLUME
1	1	8	512	-807.60156
2	2	1	64	-72.25
3	3	7	448	-727.83594
4	4	1	64	-157.57031
5	5	2	128	-256.17969
6	6	49542	3170688	96142397.1
7	7	1	64	-100.46875
8	8	3	192	-273.21094
9	9	1	64	-39.125
10	10	1	64	-9.5
11	11	3	192	-168.5625
12	12	41	2624	-3914.6953
13	13	3	192	-179.21875
14	14	1	64	-43.773438
15	15	1	64	-74.046875
16	16	8	512	-778.64844
17	17	1	64	-18.515625
18	18	3	192	-120.27344
19	19	5	320	-222.00781
20	20	7	448	481.710938
21	21	1	64	57.414063
22	22	306	19584	-108180.04
23	23	2	128	-128.65625
24	24	1	64	0.242188
25	25	1	64	47.367188
26	26	20	1280	-1333.0781
27	27	2	128	-132.96875
28	28	1	64	11.460938
29	29	1	64	-90.03125
30	30	3	192	98.40625
31	31	5	320	-316.50781
32	32	20	1280	-1944.375
33	33	3	192	-124.32031
34	34	3	192	-459.07813
35	35	4	256	-330.82031
36	36	18	1152	-1936.3438
37	37	93	5952	-13940.859
38	38	2	128	-64.257813
39	39	5	320	-130.13281
40	40	3	192	-83.695313
41	41	1	64	-70.179688
42	42	2	128	-6.304688
43	43	24	1536	-1007.8203
44	44	1	64	-8.203125
45	45	6	384	-420.1875
46	46	1	64	-36.804688

OBJECTID *	Value	Count	AREA	VOLUME
47	47	2	128	-96.257813
48	48	1	64	-143.08594
49	49	1	64	-182.67969
50	50	3	192	-86.25
51	51	1	64	-112.16406
52	52	4	256	-354.78906
53	53	1	64	-39.070313
54	54	1	64	-149.96875
55	55	1	64	-6.28125
56	56	1	64	-121.25781
57	57	1	64	-53.679688
58	58	2	128	-79.40625
59	59	2	128	-348.03125
60	60	1	64	-15.90625
61	61	5	320	-330.58594
62	62	1	64	-4.914063
63	63	2	128	-47.125
64	64	1	64	-32.484375
65	65	2	128	-39.546875
66	66	1	64	-8.28125
67	67	2	128	-10.992188
68	68	14	896	-293.46094
69	69	2	128	-65.90625
70	70	10	640	-913.99219
71	71	31	1984	-3511.7422
72	72	2	128	-68.679688
73	73	1	64	-34.664063
74	74	42	2688	-2486.8125
75	75	1	64	-37.96875
76	76	148	9472	-53136.648
77	77	1	64	-38.085938
78	78	1	64	-9.976563
79	79	1	64	-24.8125
80	80	109	6976	-37318.078
81	81	1	64	-18.554688
82	82	4	256	-328.0625
83	83	2	128	-38.523438
84	84	1	64	-21.109375
85	85	2	128	-74.398438
86	86	3	192	-84.710938
87	87	7	448	-326.20313
88	88	1	64	-32.835938
89	89	2	128	-58.65625
90	90	1	64	-54.921875
91	91	57	3648	-6648.3438
92	92	22	1408	-2567.8438

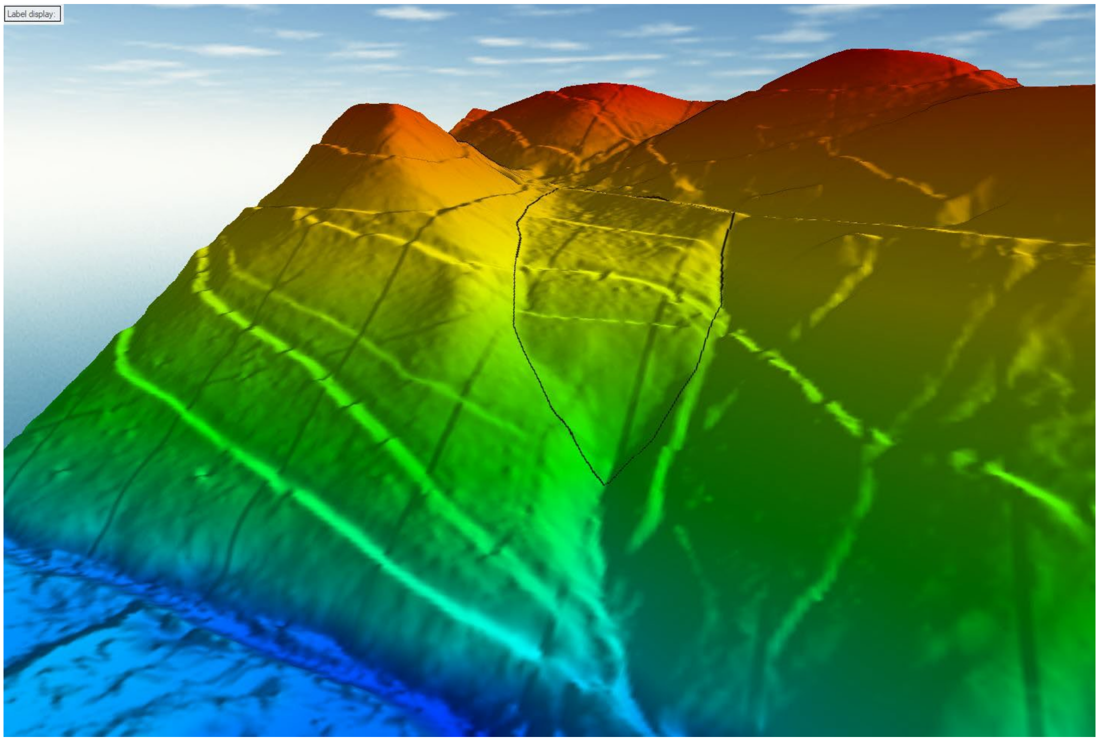
OBJECTID *	Value	Count	AREA	VOLUME
93	93	1	64	-12.796875
94	94	71	4544	-11544.82
95	95	1	64	-16.609375
96	96	2	128	-99.132813
97	97	2	128	170.828125
98	98	1	64	111.015625
99	99	2	128	-86.117188
100	100	81	5184	-17240.758
101	101	1	64	267.632813
102	102	1	64	48.296875
103	103	2	128	-221.35938
104	104	1	64	-17.335938
105	105	32	2048	-7236.9219
106	106	1	64	-24.765625
107	107	1	64	-25.8125
108	108	4	256	-191.90625
109	109	21	1344	-2728.9063
110	110	1	64	-10.226563
111	111	1	64	-29.6875
112	112	1	64	-55.523438
113	113	1	64	-34.210938
114	114	2	128	-33.929688
115	115	1	64	-61.1875
116	116	3	192	-473.89063
117	117	1	64	-18.15625
118	118	1	64	-98.132813
119	119	1	64	-174.26563
120	120	2	128	-133.90625
121	121	2	128	-32.109375
122	122	2	128	-132.77344
123	123	1	64	-0.5
124	124	1	64	-5.726563
125	125	7	448	-685
126	126	2	128	-71.289063
127	127	1	64	-37.25
128	128	9	576	-1444.1563
129	129	10	640	-2004.6875
130	130	7	448	-448.80469
131	131	1	64	-87.171875
132	132	1	64	-26.695313
133	133	2	128	-71.851563
134	134	1	64	-61.539063
135	135	7	448	-731.88281
136	136	1	64	-73.46875
137	137	3	192	-292.63281
138	138	35	2240	-4683.8984

OBJECTID *	Value	Count	AREA	VOLUME
139	139	2	128	441.671875
140	140	2	128	-62.945313
141	141	1	64	29.773438
142	142	6	384	-809.16406
143	143	2	128	-39.507813
144	144	12	768	-2418.2578
145	145	8	512	-633.07813
146	146	2	128	-256.8125
147	147	3	192	-861.38281
148	148	1	64	-42.734375
149	149	23	1472	-4891.2344
150	150	1	64	-1.78125
151	151	1	64	-55.132813
152	152	2	128	-183.64844
153	153	1	64	-100.73438
154	154	1	64	-23.289063
155	155	3	192	-127.00781
156	156	4	256	-232.75
157	157	3	192	-205.60156
158	158	21	1344	-3054.1094
159	159	48	3072	-6767.2188
160	160	1	64	15.25
161	161	3	192	164.953125
162	162	16	1024	-1000.2891

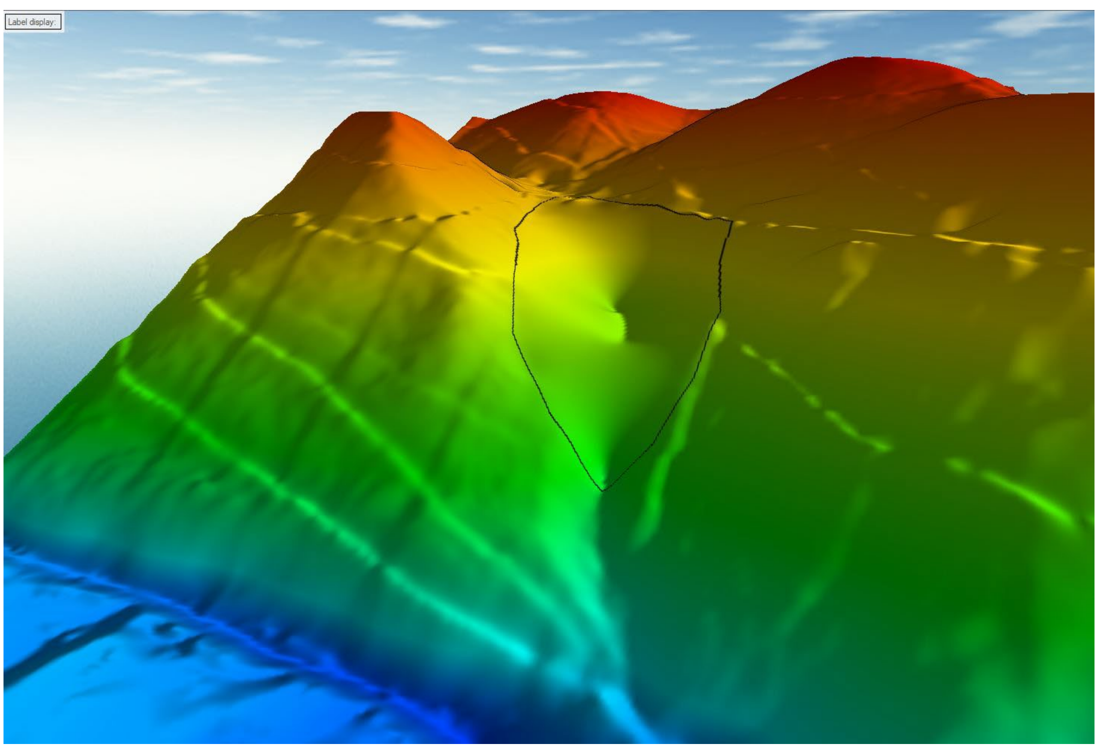
95821948.7	CF
3548961.06	CY

Unique ID: CBC_825221207

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

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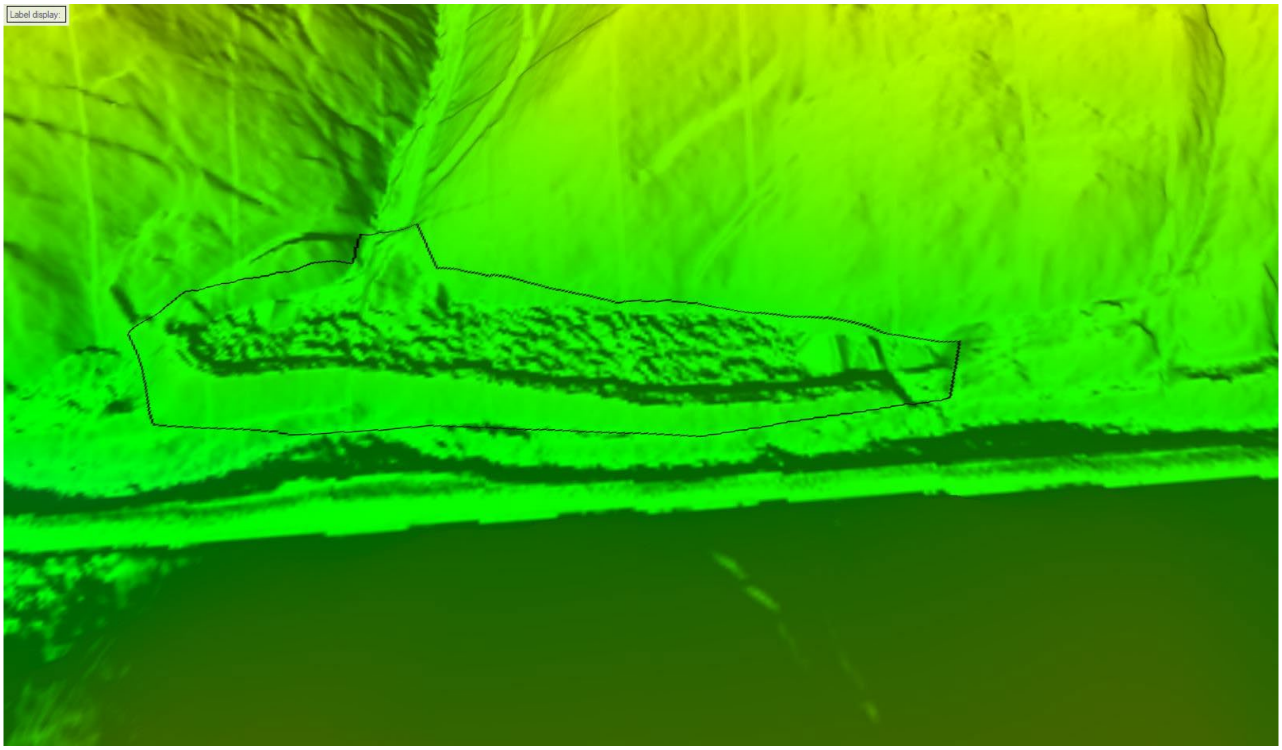
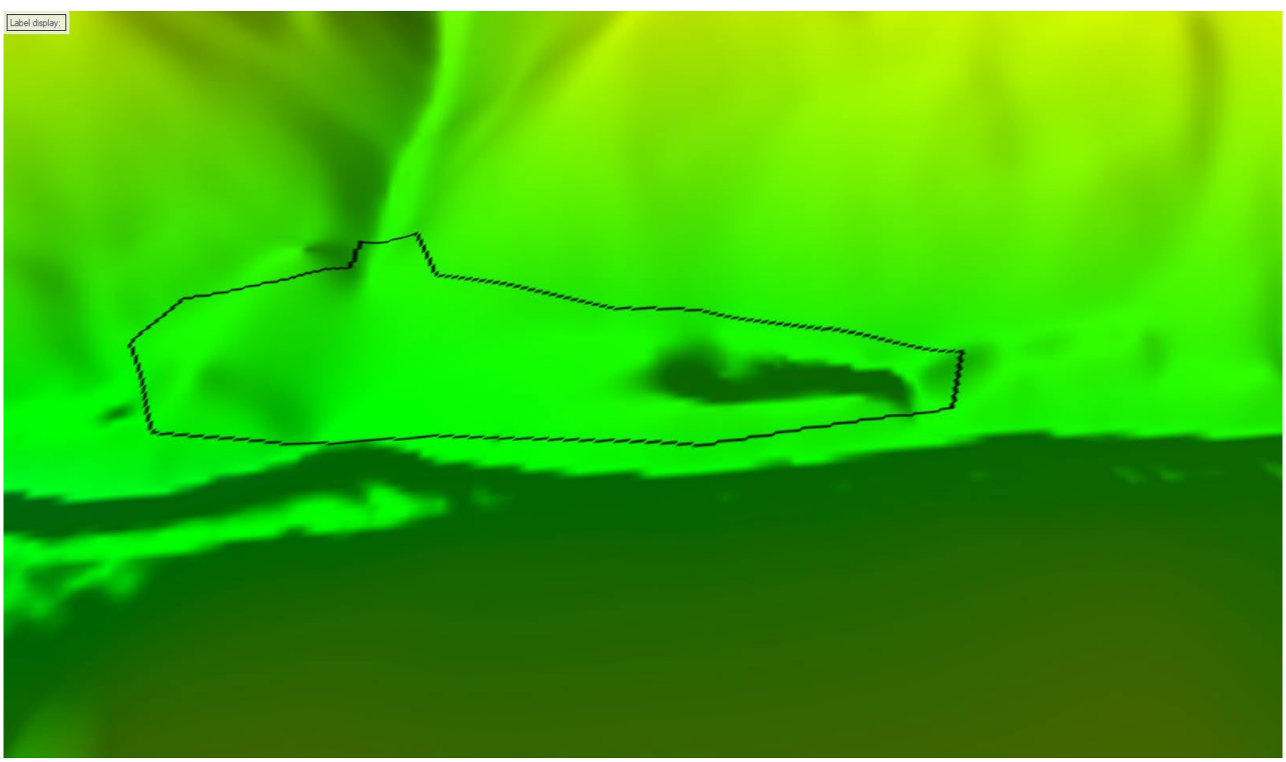
OBJECTID *	Value	Count	AREA	VOLUME
1	1	8	96.754251	38.847269
2	2	3	36.282844	-17.738378
3	3	6321	76447.9525	1160590.2
4	4	1	12.094281	0.693886
5	5	420	5079.59817	-6912.710035
6	6	1	12.094281	0.544774
7	7	2	24.188563	-2.688438
8	8	2	24.188563	1.820343
9	9	2	24.188563	-8.304484
10	10	2	24.188563	-2.158428
11	11	4	48.377125	-6.16082
12	12	49	592.619787	-439.513153
13	13	1	12.094281	3.084101
14	14	4	48.377125	-12.856079
15	15	12	145.131376	-39.31232
16	16	3	36.282844	-8.400447
17	17	56	677.279757	-528.024927
18	18	1	12.094281	3.739601
19	19	94	1136.86245	-711.610862
20	20	10	120.942814	24.852921
21	21	1	12.094281	-3.721885
22	22	1	12.094281	-7.129307
23	23	1	12.094281	-0.735224
24	24	2	24.188563	-23.233363
25	25	1	12.094281	-1.737667
26	26	1	12.094281	-7.632743
27	27	98	1185.23957	-1333.741464
28	28	1	12.094281	-0.013287
				1150596.36 CF
				42614.67999 CY

Unique ID: CBC_825221208

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

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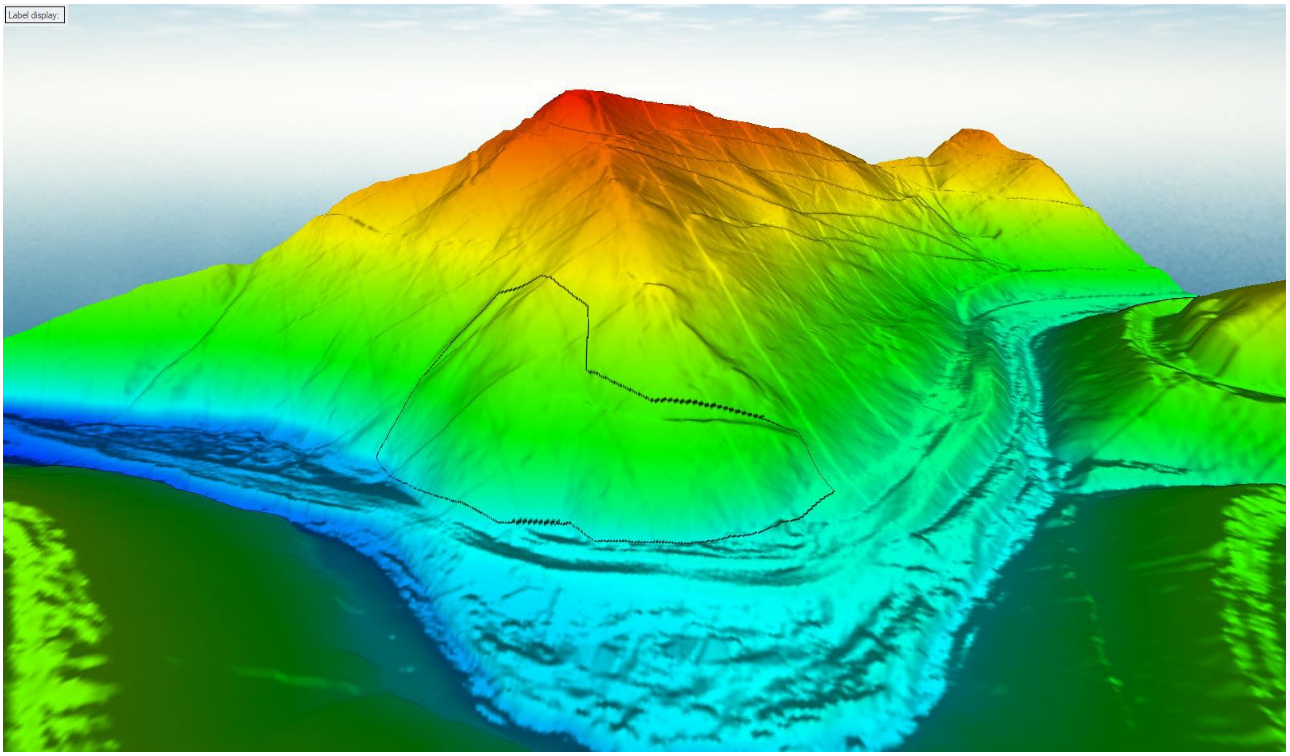
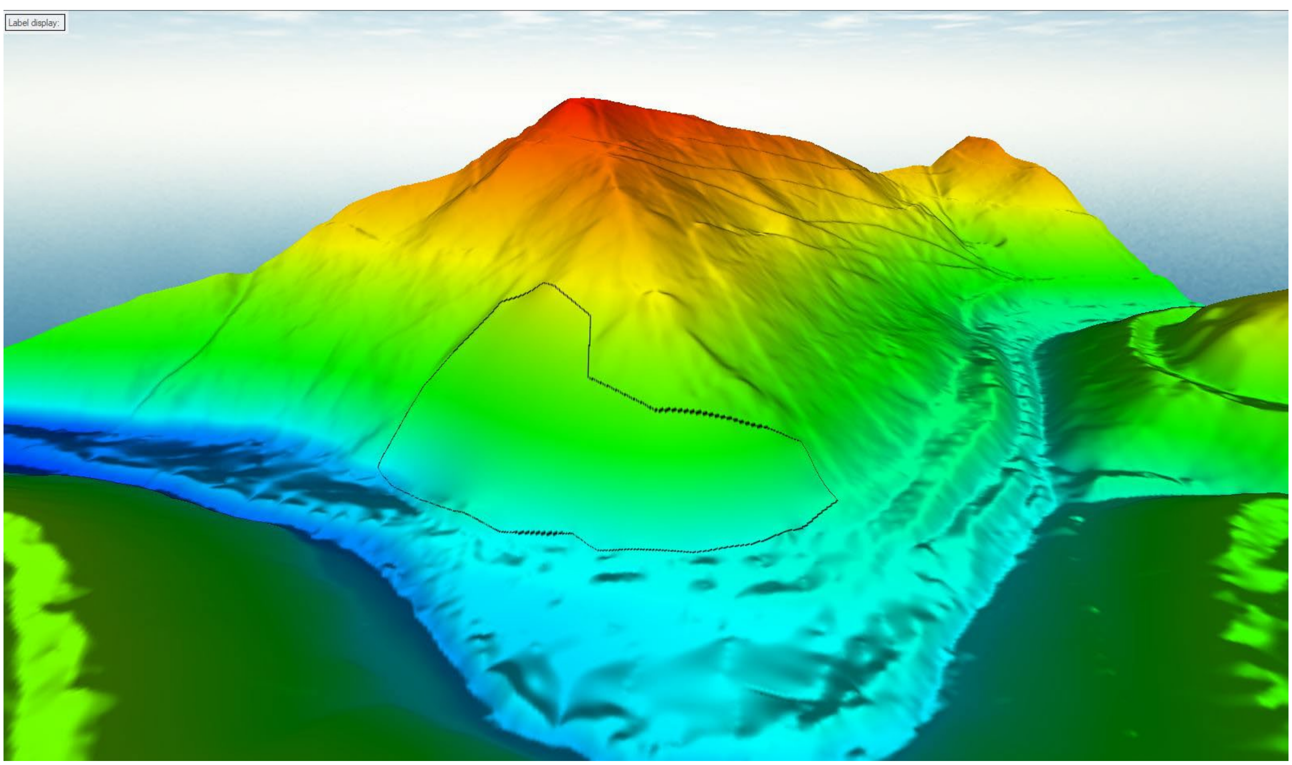
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	16	784	492.655762	
2	2	1	49	-3.128296	
3	3	780	38220	230297.9663	
4	4	1	49	-20.94104	
5	5	2	98	14.062378	
6	6	533	26117	-70307.68469	
7	7	4	196	-55.232666	
8	8	2	98	-26.539673	
9	9	2	98	-39.692871	
10	10	1	49	-14.558838	
11	11	1	49	-6.49585	
12	12	80	3920	1361.275269	
13	13	1	49	-48.168579	
14	14	211	10339	-43151.6897	
15	15	3	147	-197.806396	
16	16	3	147	32.957764	
				118326.9789	CF
				4382.480699	CY

Unique ID: CBC_825221209

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

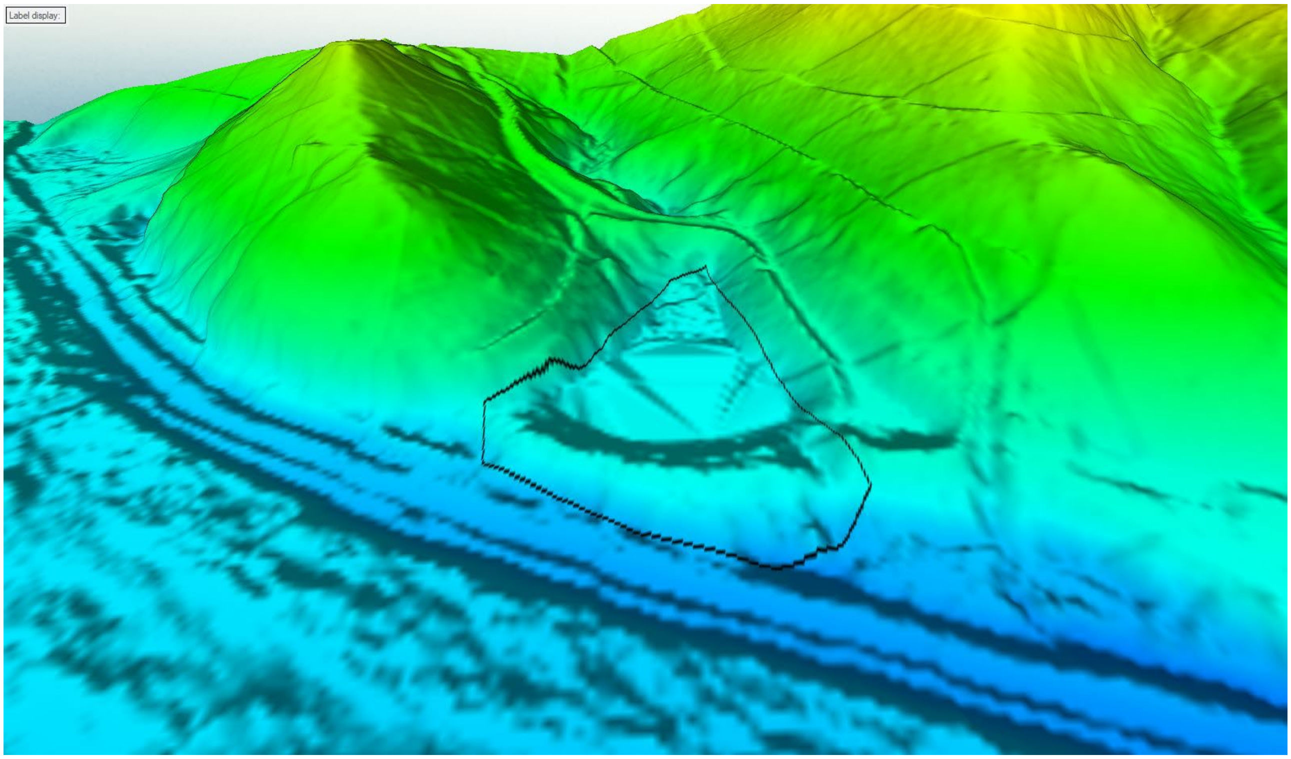
5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

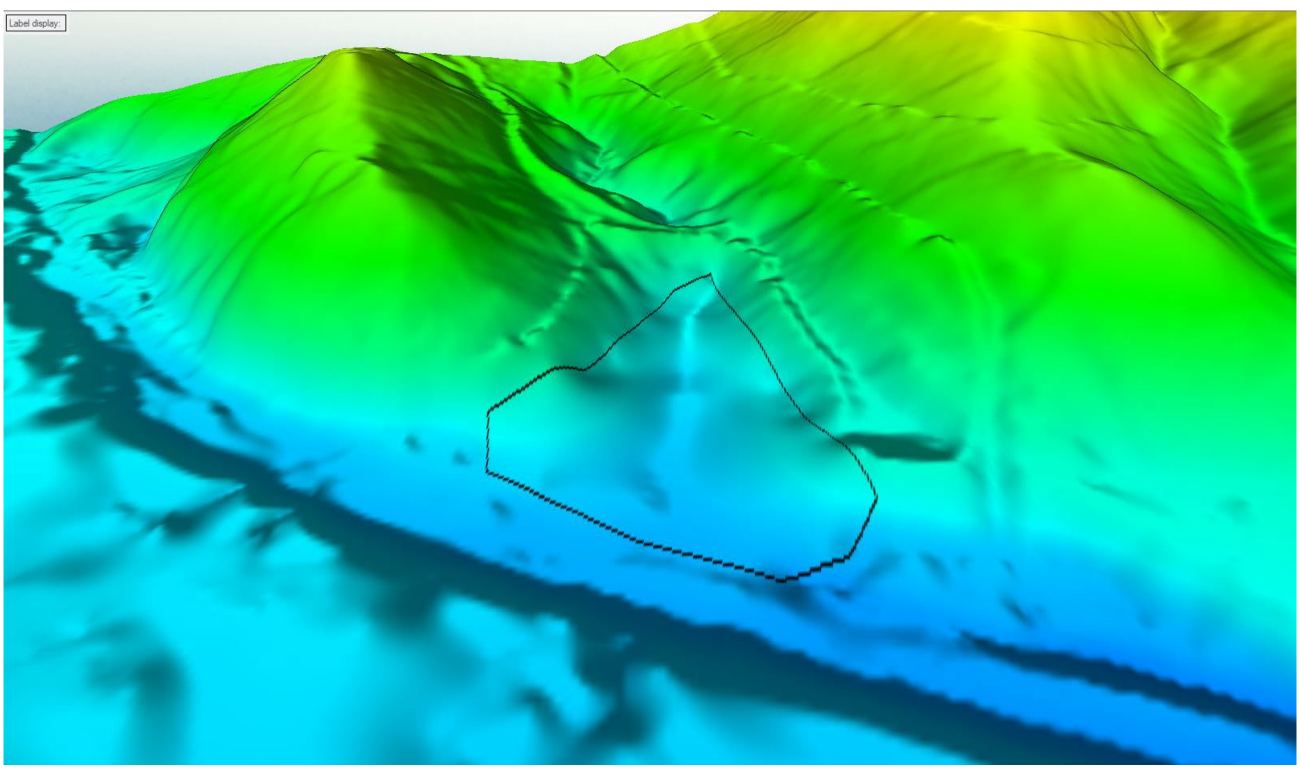
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	312	3358.326617	-3339.951045	
2	2	3	32.291602	6.929765	
3	3	99	1065.622869	-1318.794495	
4	4	1	10.763867	1.440088	
5	5	8649	93096.68881	999254.7455	
6	6	2	21.527735	7.243799	
7	7	3	32.291602	4.571227	
8	8	2	21.527735	-3.354511	
9	9	1	10.763867	-3.220488	
10	10	2	21.527735	-9.033397	
11	11	9	96.874806	-82.957462	
12	12	2	21.527735	-6.858812	
13	13	1	10.763867	-1.357309	
14	14	1	10.763867	-0.10643	
15	15	1	10.763867	-3.52401	
16	16	1	10.763867	-0.501928	
17	17	6	64.583204	22.748393	
18	18	12	129.166408	-51.104719	
19	19	16	172.221878	156.727795	
20	20	3	32.291602	-17.436099	
21	21	2	21.527735	-3.266476	
22	22	1	10.763867	-0.198406	
23	23	1	10.763867	-1.663459	
24	24	1	10.763867	-9.348745	
25	25	8	86.110939	-48.419008	
26	26	1	10.763867	0.855381	
27	27	1	10.763867	1.223286	
28	28	1	10.763867	-5.87335	
29	29	5	53.819337	3.969439	
30	30	5	53.819337	-34.295374	
31	31	1	10.763867	0.41258	
32	32	12	129.166408	-68.435702	
33	33	23	247.568949	73.728287	
34	34	12	129.166408	-94.579338	
35	35	29	312.152153	146.858727	
36	36	46	495.137899	-342.233694	
37	37	3	32.291602	2.969524	
38	38	1	10.763867	1.185182	
39	39	51	548.957235	-601.102602	
40	40	1141	12281.57266	-19257.32737	
41	41	4	43.055469	5.969269	
42	42	2	21.527735	-9.028141	
43	43	1	10.763867	1.697622	
				974379.3035	CF
				36088.12235	CY

Unique ID: CBC_825221210

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

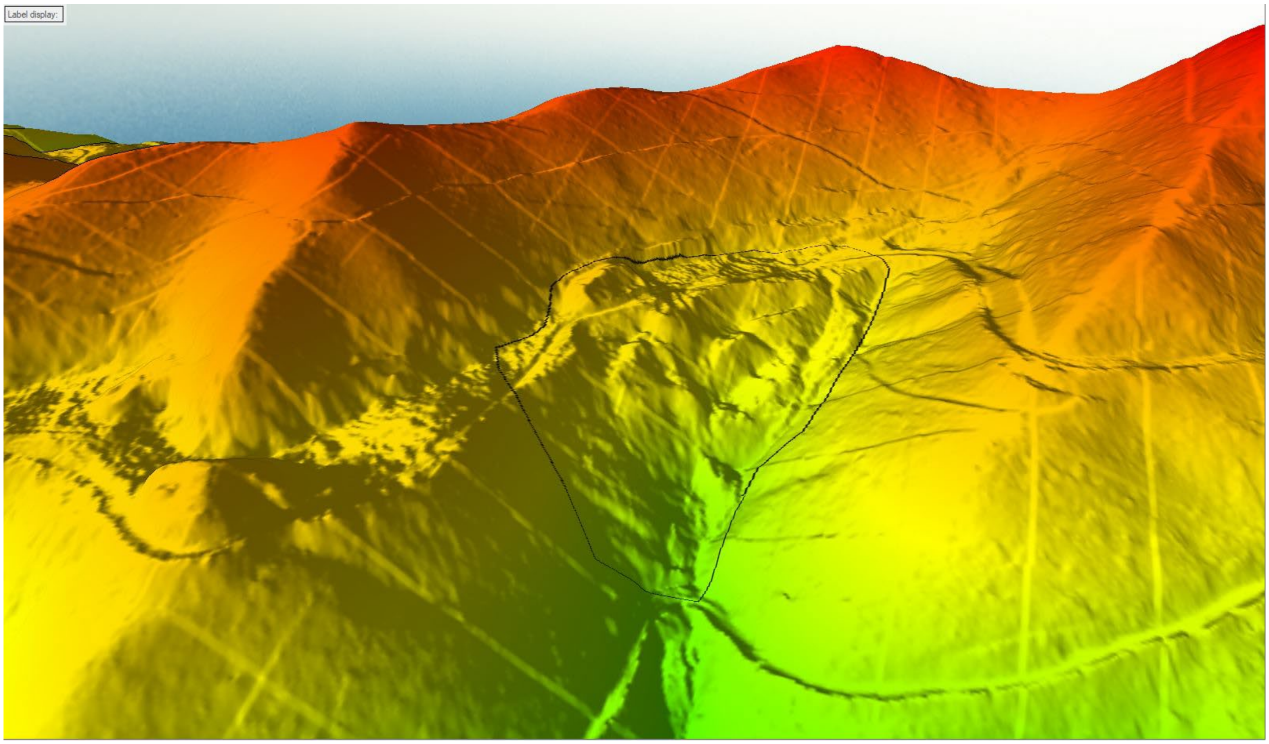
5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

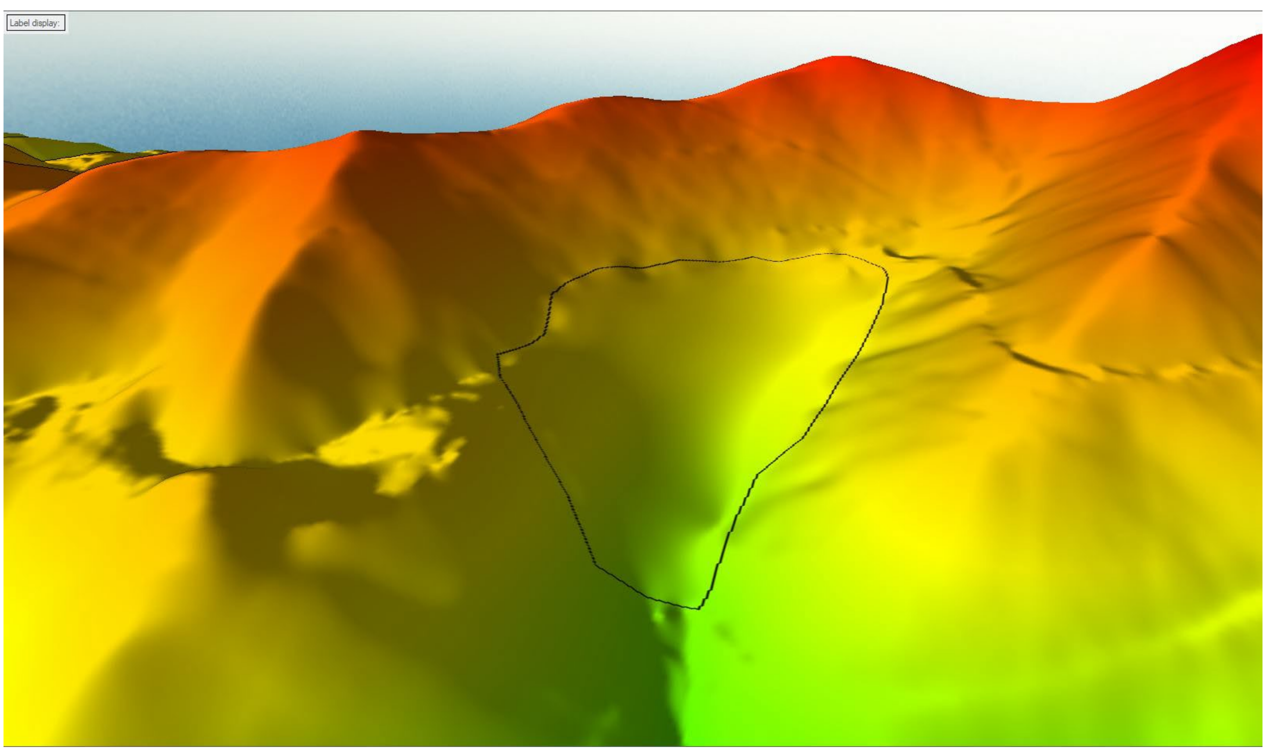
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	2	21.527735	14.407447	
2	2	20	215.277347	-271.934813	
3	3	1942	20903.43042	88591.8395	
4	4	291	3132.285402	-8140.534714	
5	5	101	1087.150603	-1394.743355	
6	6	1	10.763867	3.844614	
7	7	1	10.763867	7.228032	
8	8	1	10.763867	-0.533463	
9	9	1	10.763867	12.193443	
10	10	1	10.763867	-5.611875	
11	11	29	312.152153	-162.3896	
12	12	1	10.763867	3.744754	
13	13	1	10.763867	-2.772432	
14	14	23	247.568949	-95.652834	
15	15	2	21.527735	-5.745897	
16	16	12	129.166408	-73.763763	
17	17	12	129.166408	-88.322314	
				78391.25273	CF
				2903.379731	CY

Unique ID: CBC_825221211

Current Surface:



Historical Surface:



Process Documentation:

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2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

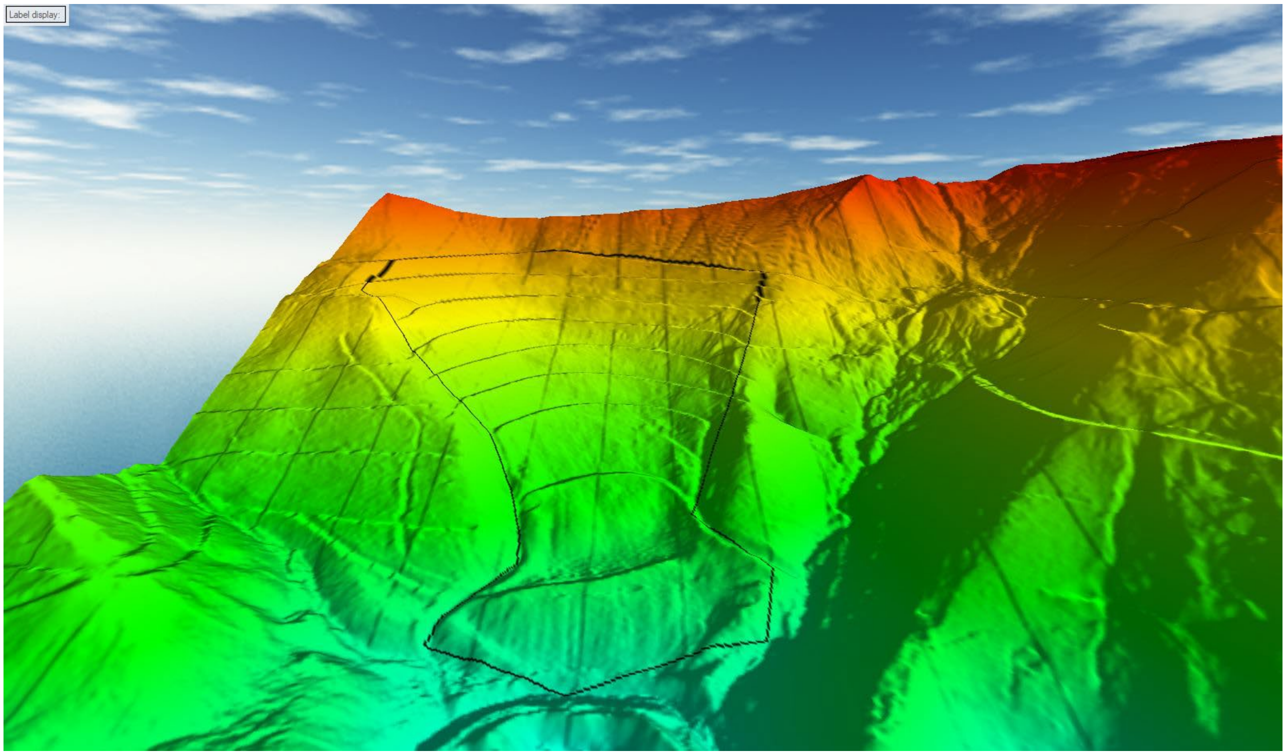
5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

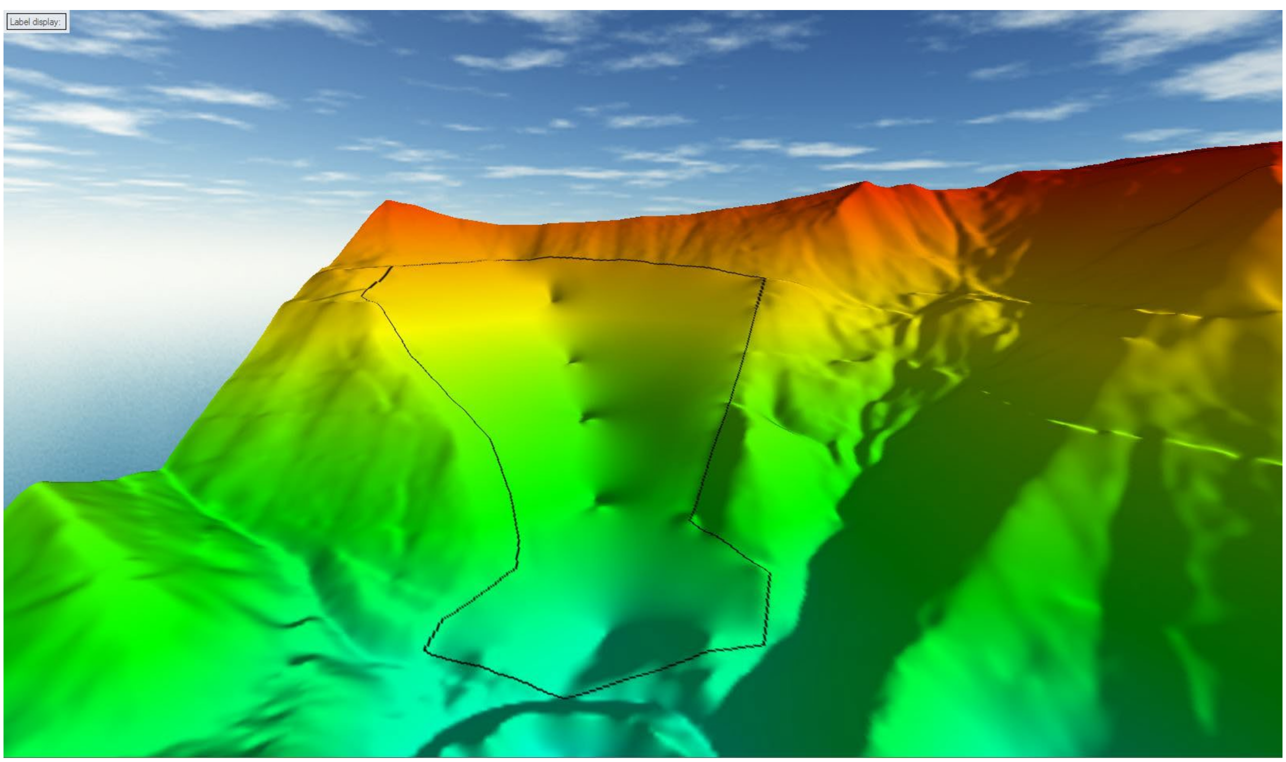
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	2	72	42.811523	
2	2	1186	42696	-204173.6572	
3	3	3	108	25.602539	
4	4	1	36	1.248047	
5	5	171	6156	11321.05957	
6	6	3	108	73.608398	
7	7	5252	189072	2972244.155	
8	8	2	72	-4.605469	
9	9	1	36	-1.116211	
10	10	5	180	-41.317383	
11	11	16	576	-386.630859	
12	12	30	1080	-2491.242188	
13	13	173	6228	-33532.03125	
14	14	78	2808	-5624.630859	
15	15	34	1224	-1645.259766	
16	16	19	684	-605.021484	
17	17	1	36	5.097656	
18	18	1	36	-16.655273	
19	19	1	36	-8.525391	
20	20	8	288	-121.174805	
				2735061.715	CF
				101298.582	CY

Unique ID: CBC_825221213

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

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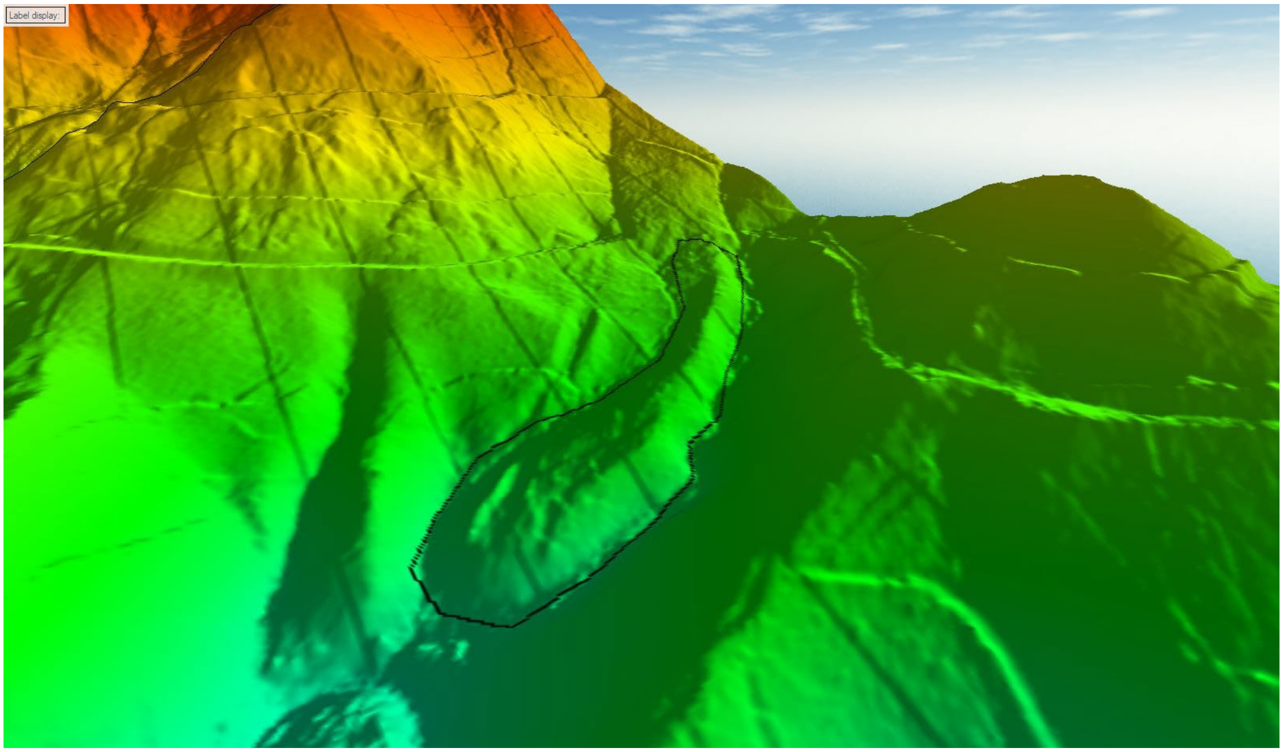
OBJECTID *	Value	Count	AREA	VOLUME
1	1	528	13200	-36313.76343
2	2	277	6925	-16169.32983
3	3	10	250	-324.212646
4	4	22171	554275	9566584.625
5	5	1	25	25.823975
6	6	2186	54650	-200610.2783
7	7	1	25	1.452637
8	8	1	25	-0.67749
9	9	1	25	5.792236
10	10	19	475	407.702637
11	11	1	25	5.114746
12	12	2	50	10.534668
13	13	2	50	30.841064
14	14	1	25	6.04248
15	15	1	25	1.715088
16	16	49	1225	1822.20459
17	17	2	50	12.957764
18	18	26	650	978.210449
19	19	5	125	-36.04126
20	20	3	75	71.105957
21	21	1	25	4.956055
22	22	1	25	5.712891
23	23	1	25	23.272705
24	24	1	25	-1.171875
25	25	5	125	143.261719
26	26	2	50	61.260986
27	27	9	225	-175.537109
28	28	1	25	4.101563
29	29	1	25	-1.080322
30	30	1	25	8.276367
31	31	1	25	-8.062744
32	32	28	700	-1322.253418
33	33	7	175	-67.919922
34	34	2	50	15.740967
35	35	1	25	-1.940918
36	36	1	25	-7.092285
37	37	1	25	-1.177979
38	38	2	50	1.867676
39	39	11	275	-234.851074
40	40	6	150	-55.200195
41	41	1	25	-8.874512
42	42	2	50	-5.13916
43	43	1	25	-0.866699
44	44	1	25	-5.371094
45	45	14	350	-248.638916
46	46	1	25	-3.149414

OBJECTID *	Value	Count	AREA	VOLUME
47	47	1	25	-4.095459
48	48	106	2650	-2940.441895
49	49	1	25	-0.177002
50	50	1	25	-2.923584
51	51	2	50	-9.552002
52	52	2	50	-4.345703
53	53	4	100	-27.740479
54	54	1	25	-7.501221
55	55	2	50	18.798828
56	56	7	175	-135.058594
57	57	7	175	-219.622803
58	58	2	50	-61.38916
59	59	4	100	-264.825439
60	60	1	25	-11.175537
61	61	1	25	-25.10376
62	62	1	25	-3.80249
63	63	1	25	-48.00415
64	64	67	1675	-1851.324463
65	65	1	25	-21.209717
66	66	2	50	16.998291
67	67	1	25	-13.079834
68	68	6	150	-213.391113
69	69	1	25	1.519775
70	70	40	1000	-869.726563
71	71	1	25	4.071045
72	72	1	25	9.912109
73	73	1	25	-2.062988
74	74	1	25	5.096436
75	75	1	25	1.45874
76	76	1	25	1.000977
77	77	75	1875	-1600.933838
78	78	3	75	-42.669678
79	79	14	350	-230.0354
80	80	2435	60875	-195665.3076
81	81	1	25	2.423096
82	82	1	25	0.036621
83	83	1	25	-9.088135
84	84	1	25	-2.966309
85	85	8	200	-109.094238
86	86	1	25	-0.158691
87	87	1	25	-2.825928
88	88	8	200	-140.637207
89	89	1	25	-0.323486
90	90	11	275	-137.908936
91	91	13	325	-202.581787
92	92	1	25	-4.315186

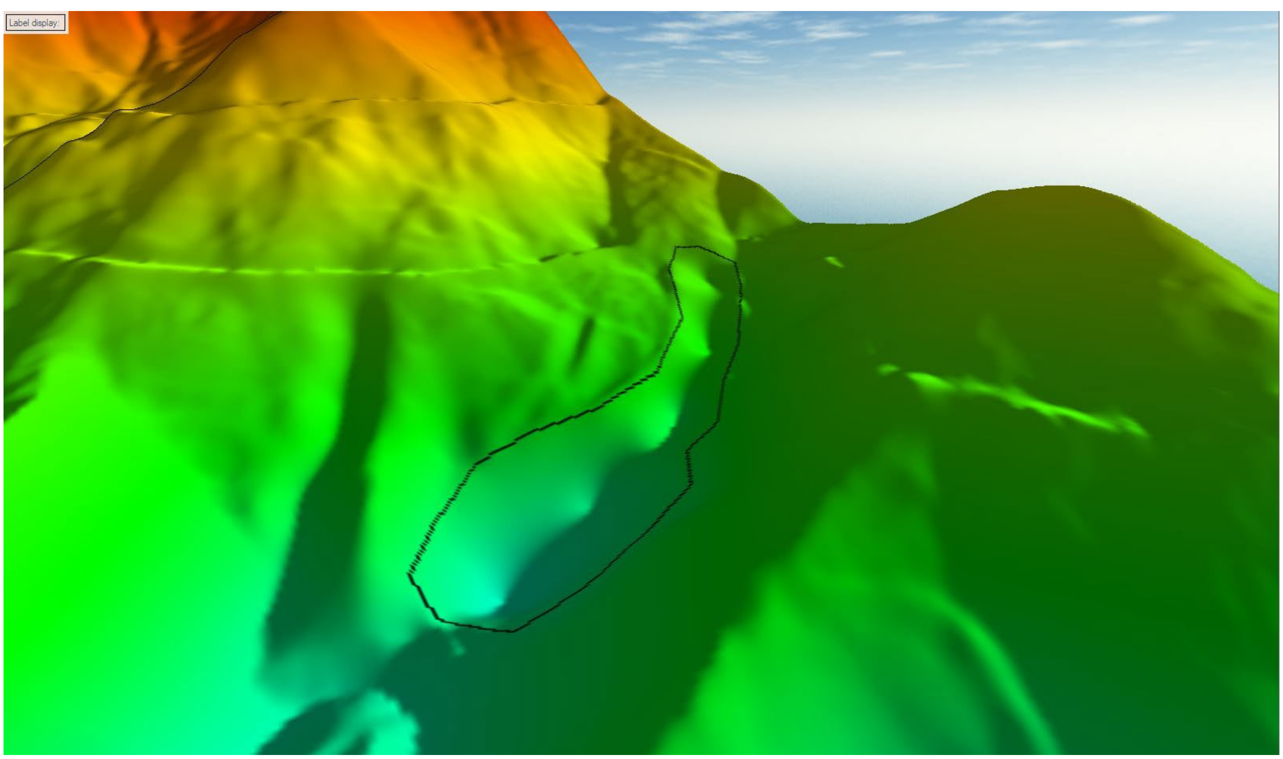
OBJECTID *	Value	Count	AREA	VOLUME	
93	93	1	25	-7.293701	
94	94	12	300	220.88623	
95	95	1	25	-1.763916	
96	96	1	25	4.345703	
97	97	3	75	9.655762	
98	98	47	1175	1552.130127	
99	99	1	25	3.259277	
100	100	1	25	-1.531982	
101	101	1	25	-2.661133	
102	102	1	25	6.671143	
103	103	1	25	4.821777	
104	104	1	25	2.667236	
105	105	1	25	3.015137	
106	106	1	25	16.119385	
107	107	78	1950	2779.504395	
108	108	3	75	18.499756	
109	109	1	25	18.469238	
110	110	1	25	8.483887	
111	111	1	25	2.758789	
112	112	1	25	19.65332	
113	113	1	25	13.342285	
114	114	1	25	2.69165	
115	115	1	25	-2.893066	
116	116	54	1350	1829.156494	
117	117	1	25	1.586914	
118	118	1	25	4.016113	
				9116311.45	CF
				337641.1648	CY

Unique ID: CBC_825221214

Current Surface:



Historical Surface:



Process Documentation:

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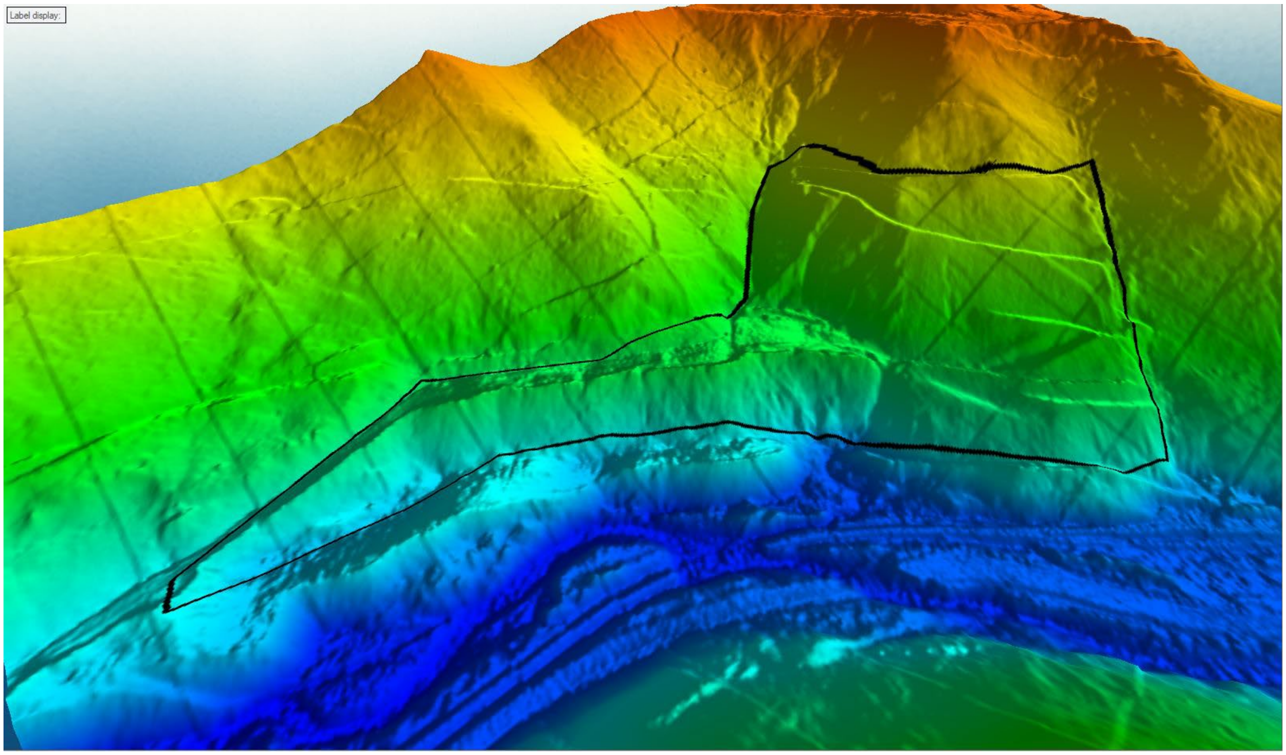
5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

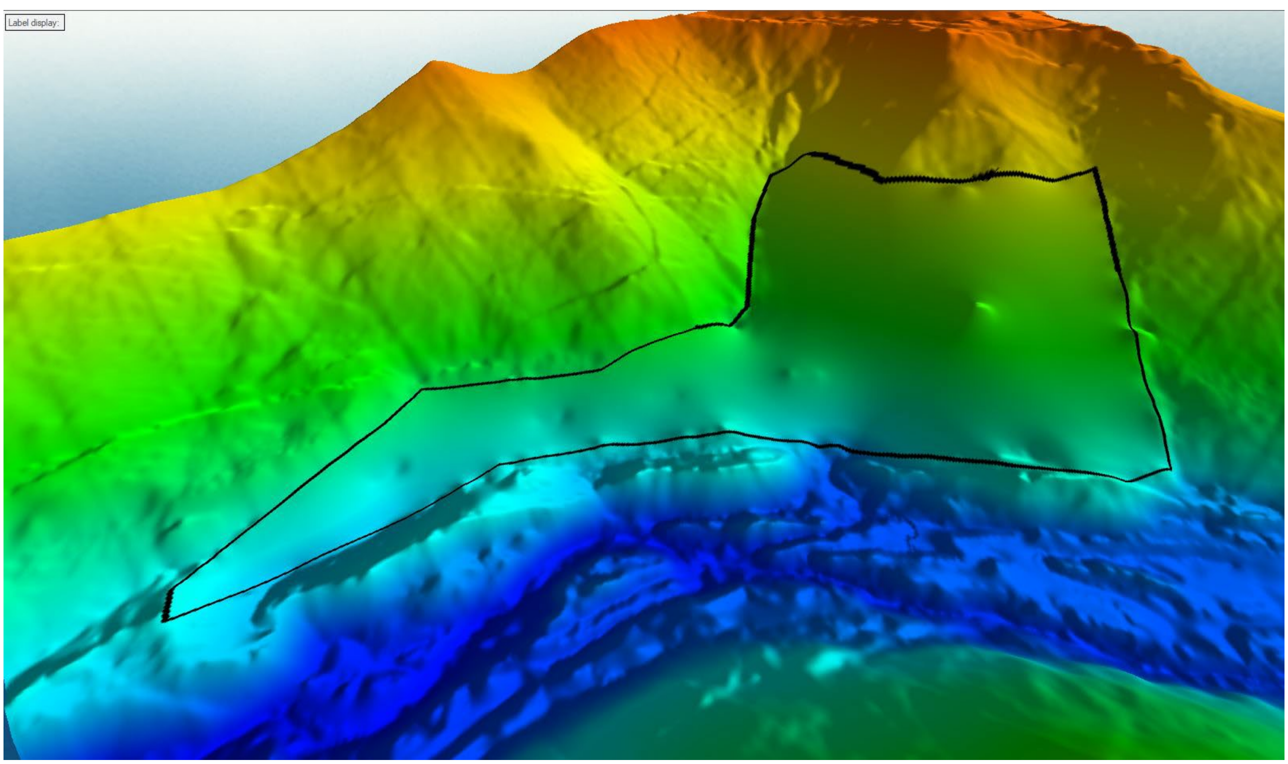
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	3035	75875	1761590.82	
2	2	2	50	-31.542969	
3	3	1	25	-2.313232	
4	4	3	75	-26.000977	
5	5	1	25	-8.94165	
6	6	1	25	-10.253906	
7	7	1	25	-1.953125	
8	8	1	25	-0.085449	
9	9	2	50	-53.399658	
10	10	9	225	-176.098633	
				1761280.231	CF
				65232.60114	CY

Unique ID: CBC_825221221

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

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6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

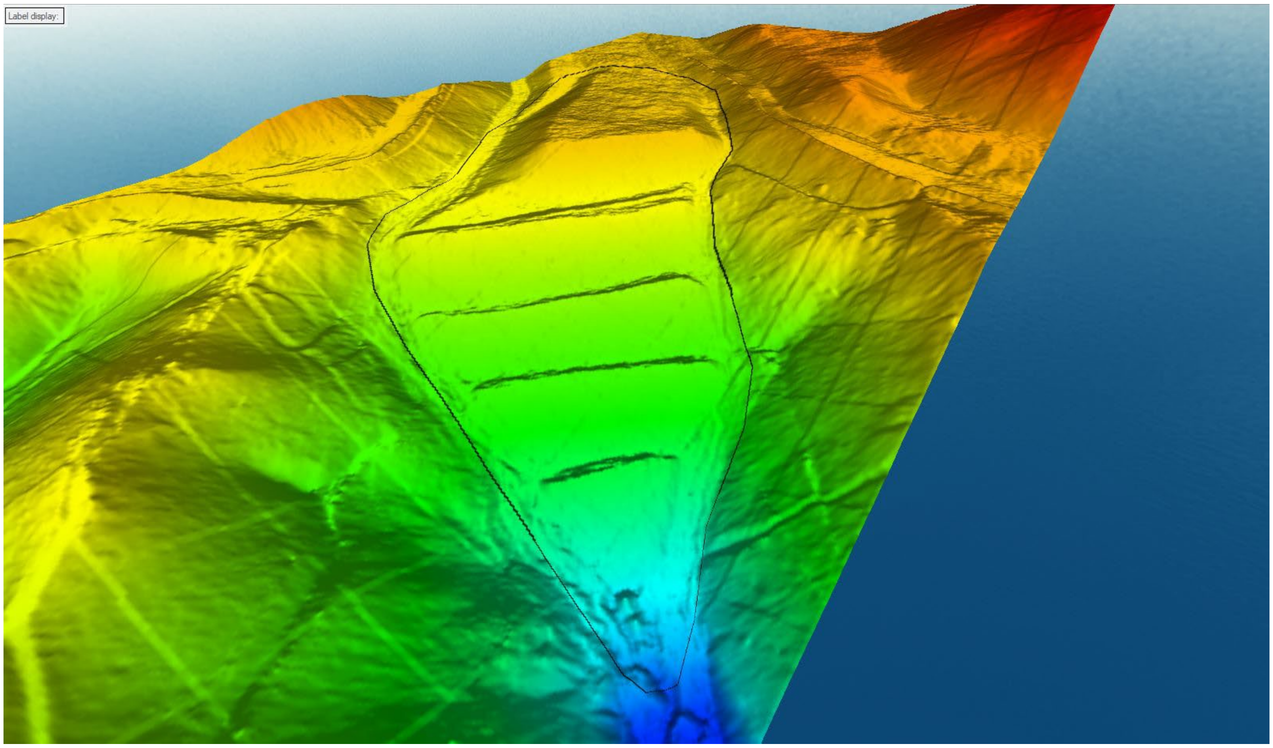
OBJECTID *	Value	Count	AREA	VOLUME
1	1	18	193.749613	-174.27558
2	2	2	21.527735	14.801632
3	3	28210	303648.6983	3439856.948
4	4	1	10.763867	-4.023311
5	5	5	53.819337	-27.834688
6	6	128	1377.775022	-1891.639317
7	7	2	21.527735	11.183017
8	8	7	75.347072	-38.258243
9	9	4	43.055469	30.135412
10	10	2	21.527735	-4.14288
11	11	8	86.110939	-158.619881
12	12	2	21.527735	-11.837363
13	13	8	86.110939	-105.729506
14	14	3	32.291602	-16.831682
15	15	105	1130.206073	-1680.539013
16	16	3	32.291602	-18.744791
17	17	1	10.763867	-2.884117
18	18	2	21.527735	-8.164877
19	19	2	21.527735	3.7868
20	20	3	32.291602	-11.137029
21	21	1610	17329.82645	-75708.1617
22	22	4	43.055469	-46.871176
23	23	1	10.763867	-3.100919
24	24	2	21.527735	-19.853764
25	25	50	538.193368	-627.668015
26	26	1	10.763867	-1.256135
27	27	49	527.429501	-467.655349
28	28	1	10.763867	-2.832873
29	29	1	10.763867	-6.062559
30	30	7	75.347072	-32.75017
31	31	430	4628.462965	-6882.909784
32	32	1	10.763867	-1.295553
33	33	1	10.763867	-2.533293
34	34	1	10.763867	1.763319
35	35	1	10.763867	-3.563429
36	36	16	172.221878	74.789957
37	37	1	10.763867	-5.192725
38	38	2	21.527735	-5.099435
39	39	115	1237.844747	-2710.12027
40	40	1	10.763867	-0.36265
41	41	1	10.763867	0.501928
42	42	3	32.291602	6.959986
43	43	11	118.402541	-133.233079
44	44	53	570.48497	-539.716235
45	45	975	10494.77068	-46498.14105
46	46	14	150.694143	-63.990613

OBJECTID *	Value	Count	AREA	VOLUME
47	47	1	10.763867	-11.306528
48	48	1	10.763867	-2.902513
49	49	2	21.527735	-14.4219
50	50	6	64.583204	-58.44575
51	51	1	10.763867	-1.242995
52	52	101	1087.150603	-1489.694541
53	53	10	107.638674	-67.979761
54	54	4	43.055469	-12.236804
55	55	16	172.221878	-100.522328
56	56	1	10.763867	-1.689738
57	57	1	10.763867	-0.629381
58	58	1	10.763867	-2.445258
59	59	7	75.347072	-27.717747
60	60	1	10.763867	-2.846013
61	61	1	10.763867	-4.007543
62	62	13	139.930276	-77.656993
63	63	2	21.527735	-17.580633
64	64	3	32.291602	-20.150717
65	65	3	32.291602	-9.665406
66	66	1	10.763867	-0.70559
67	67	3	32.291602	-8.719363
68	68	1	10.763867	1.698936
69	69	935	10064.21598	-12878.44829
70	70	1	10.763867	0.222057
71	71	4	43.055469	-16.639846
72	72	35	376.735358	-373.985263
73	73	1	10.763867	1.416437
74	74	1	10.763867	0.321917
75	75	3	32.291602	7.574914
76	76	15	161.45801	-79.906473
77	77	5	53.819337	-10.356543
78	78	1	10.763867	-0.580765
79	79	17	182.985745	-70.423706
80	80	5	53.819337	-44.57965
81	81	60	645.832042	-617.471774
82	82	3	32.291602	-18.814431
83	83	11	118.402541	-43.19212
84	84	2	21.527735	5.634212
85	85	1	10.763867	-0.135337
86	86	3	32.291602	-33.081285
87	87	2	21.527735	-17.333611
88	88	2	21.527735	-10.424869
89	89	1	10.763867	-10.325009
90	90	41	441.318562	-479.199701
91	91	1	10.763867	-1.333658
92	92	2	21.527735	-5.677572

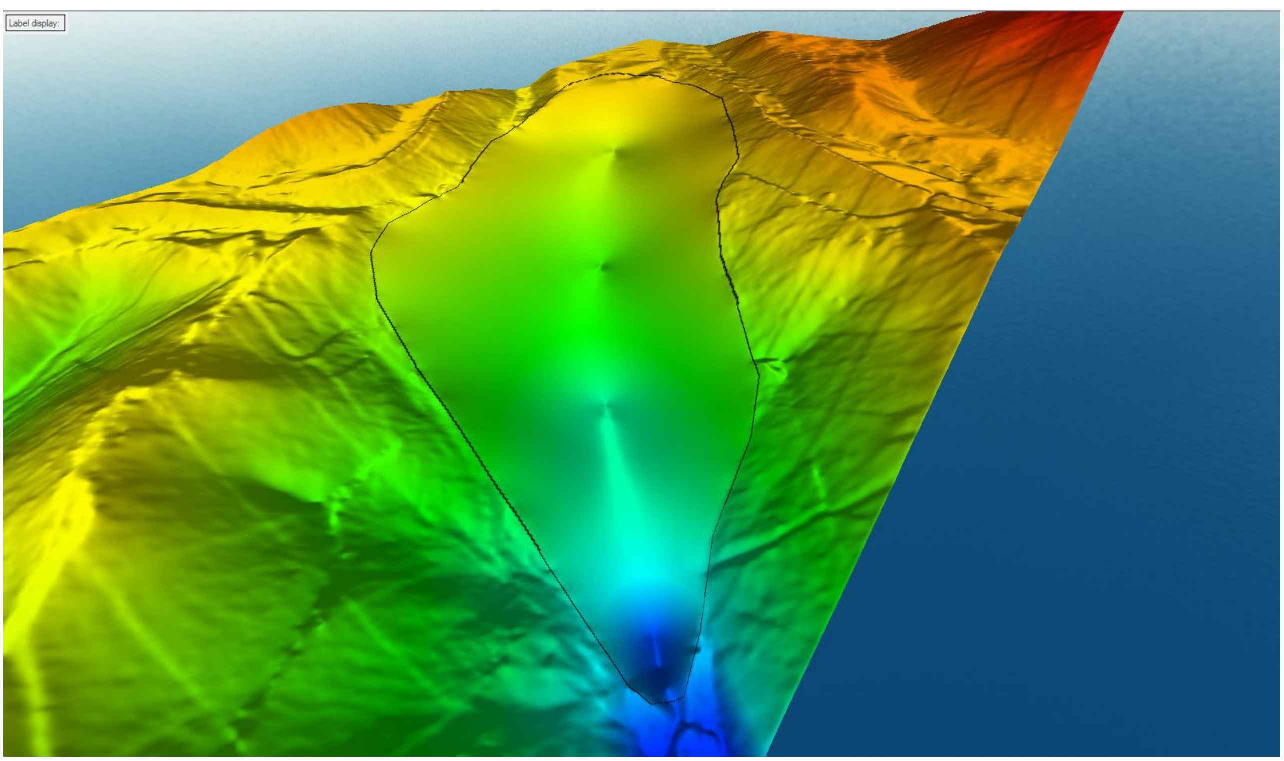
OBJECTID *	Value	Count	AREA	VOLUME	
93	93	1	10.763867	3.42415	
94	94	26	279.860551	-218.091825	
				3285241.56	CF
				121675.6133	CY

Unique ID: CBC_826221206

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

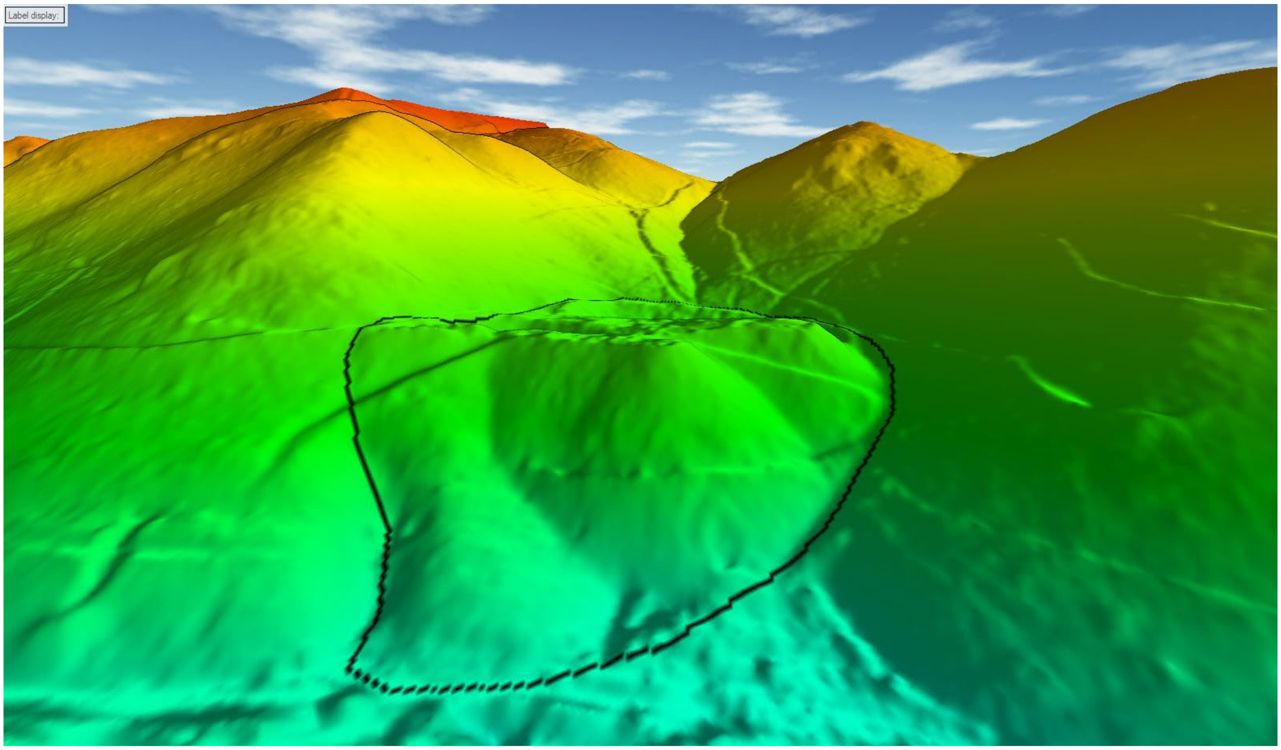
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	829	8923.246042	-12346.01921
2	2	17	182.985745	42.737494
3	3	2	21.527735	5.542235
4	4	51238	551519.0358	21454520.61
5	5	2	21.527735	2.238969
6	6	3	32.291602	-2.028737
7	7	2	21.527735	-3.434662
8	8	1	10.763867	-0.788369
9	9	4	43.055469	-11.891235
10	10	1	10.763867	-2.073411
11	11	7	75.347072	-40.327712
12	12	125	1345.48342	-825.073033
13	13	1	10.763867	0.270673
14	14	2	21.527735	0.906625
15	15	1	10.763867	1.928877
16	16	37	398.263092	-218.099709
17	17	1	10.763867	4.159961
18	18	18	193.749612	-117.493289
19	19	1	10.763867	-0.157674
20	20	1	10.763867	-0.533463
21	21	28	301.388286	-207.803607
22	22	1	10.763867	2.819734
23	23	1	10.763867	-1.045903
24	24	1	10.763867	-1.151019
25	25	1	10.763867	-5.284701
26	26	29	312.152153	-319.657428
27	27	2	21.527735	-1.471622
28	28	2	21.527735	-2.551688
29	29	24	258.332817	-148.964987
30	30	1	10.763867	-0.969694
31	31	1	10.763867	-0.517696
32	32	1	10.763867	-4.246682
33	33	1	10.763867	-0.567626
34	34	2	21.527735	-10.593054
35	35	4	43.055469	-21.188736
36	36	1	10.763867	-0.026279
37	37	73	785.762317	-576.844482
38	38	1	10.763867	0.015767
39	39	1	10.763867	-4.265077
40	40	11	118.402541	-31.335047
41	41	1	10.763867	-1.652947
42	42	6	64.583204	-16.676636
43	43	17	182.985745	-143.738099
44	44	3	32.291602	-11.284191
45	45	1	10.763867	-2.859152
46	46	1	10.763867	-0.41258

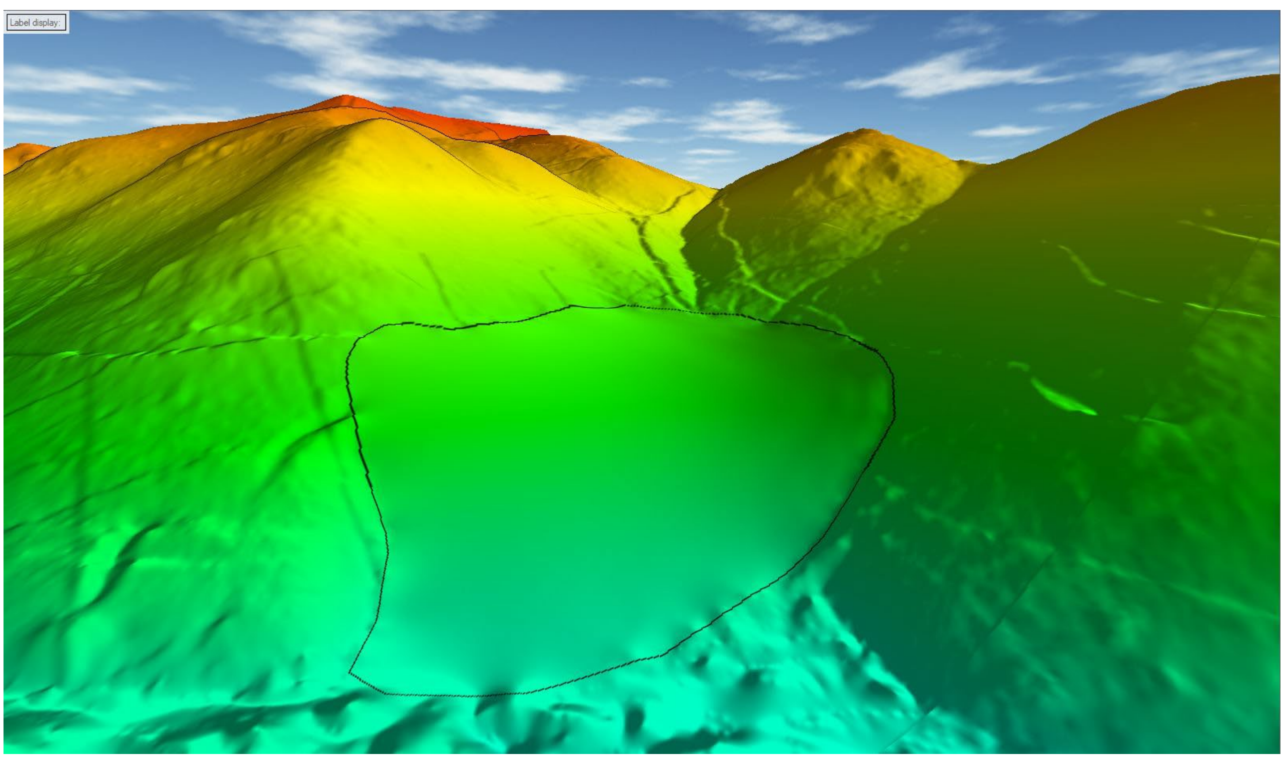
OBJECTID *	Value	Count	AREA	VOLUME	
47	47	1	10.763867	-8.227946	
48	48	1	10.763867	-0.19972	
49	49	29	312.152153	-401.981567	
50	50	10	107.638674	-25.088536	
51	51	4	43.055469	-17.814516	
52	52	4	43.055469	-15.625477	
53	53	1	10.763867	-4.409612	
54	54	1	10.763867	-6.017885	
55	55	2	21.527735	-5.58691	
56	56	2	21.527735	-1.624041	
57	57	1	10.763867	-0.754207	
58	58	4	43.055469	-14.082902	
59	59	10	107.638674	-22.076965	
60	60	2	21.527735	-3.983892	
61	61	1	10.763867	1.957783	
62	62	4	43.055469	-11.57326	
63	63	13	139.930276	-119.364351	
				21438841.74	CF
				794031.1757	CY

Unique ID: CBC_831221242

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

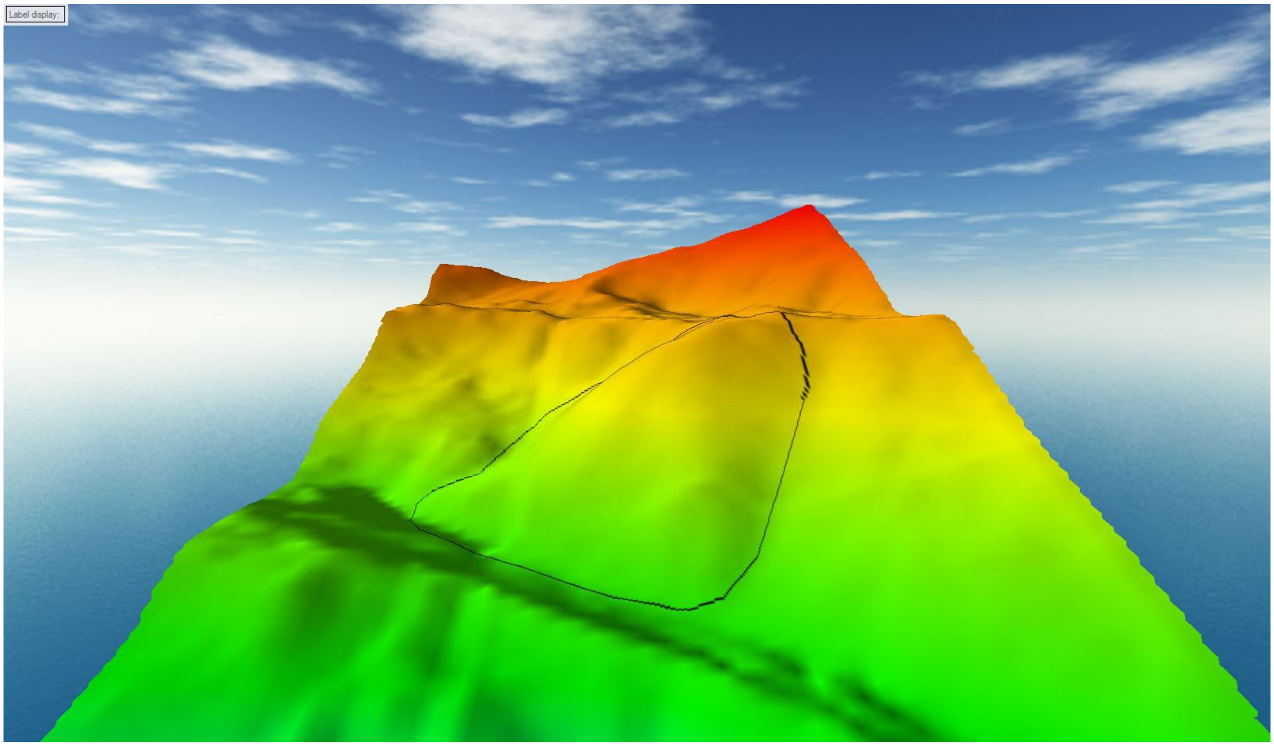
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

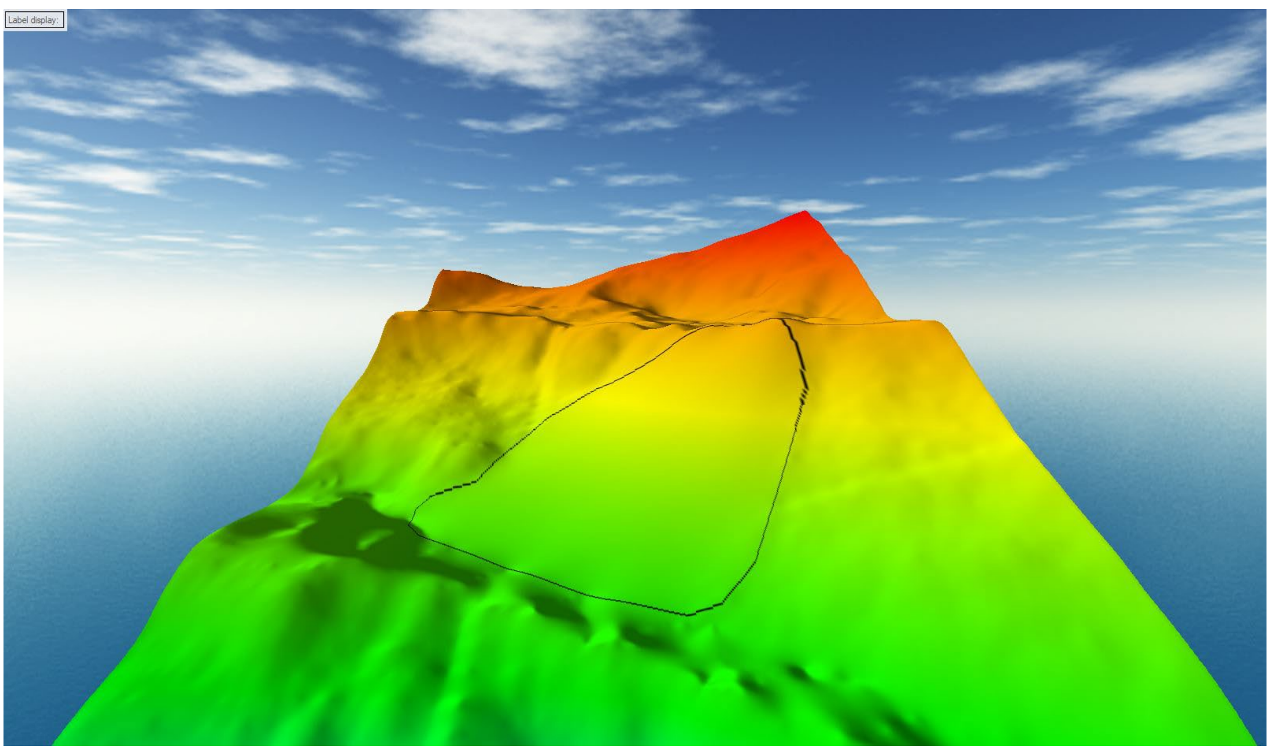
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	9466	101890.7684	1733092.68	
2	2	1167	12561.43321	-33290.1689	
3	3	3	32.291602	-2.817106	
4	4	7	75.347072	-15.015805	
5	5	1	10.763867	-1.398041	
6	6	6	64.583204	41.964892	
7	7	119	1280.900216	-2683.54303	
8	8	1	10.763867	0.578137	
9	9	1	10.763867	-2.704106	
10	10	1	10.763867	-1.802738	
11	11	1	10.763867	2.133853	
12	12	13	139.930276	-98.924566	
13	13	54	581.248837	-509.268102	
14	14	1	10.763867	1.279786	
15	15	2	21.527735	-7.810111	
16	16	4	43.055469	-7.699739	
17	17	196	2109.718003	-4558.187736	
18	18	1	10.763867	-0.241767	
19	19	26	279.860551	-70.598461	
20	20	34	365.97149	-158.648788	
21	21	4	43.055469	-5.547491	
22	22	1	10.763867	0.733183	
23	23	26	279.860551	223.465875	
24	24	1	10.763867	-0.052558	
25	25	1	10.763867	-0.814648	
				1691947.592	CF
				62664.72565	CY

Unique ID: CBC_831221243

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

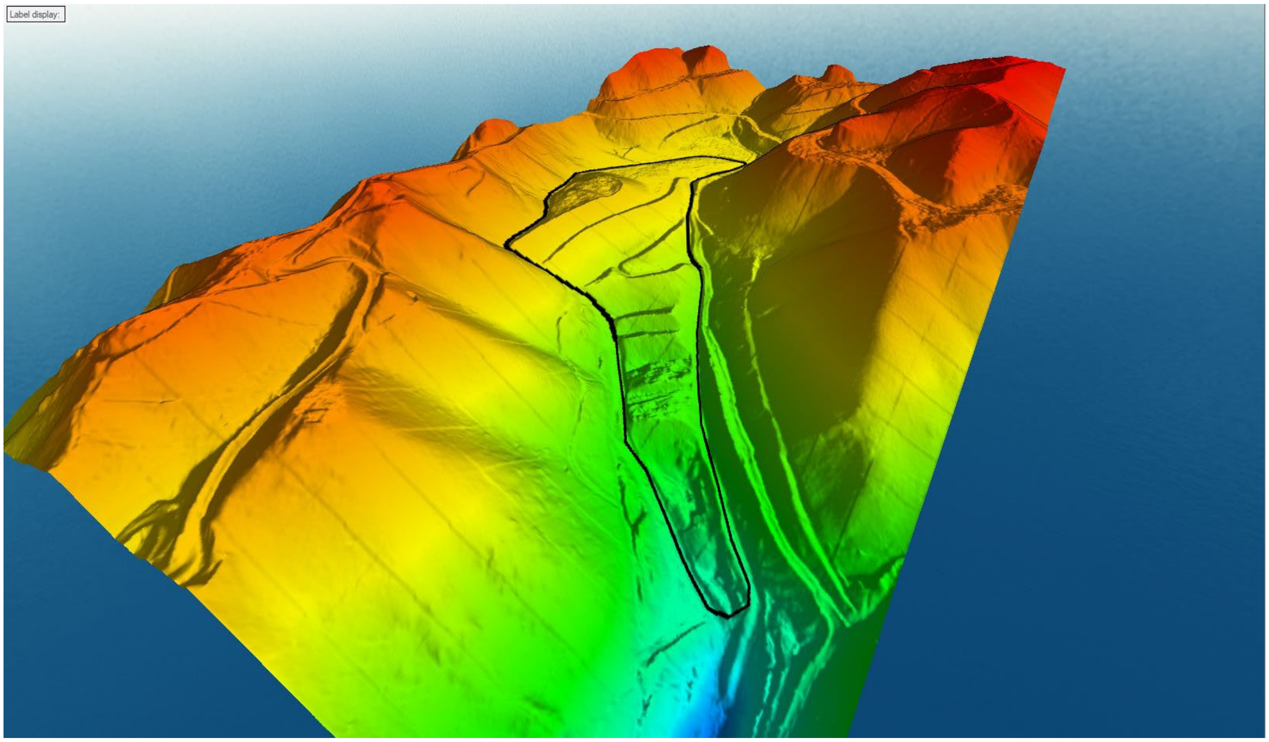
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

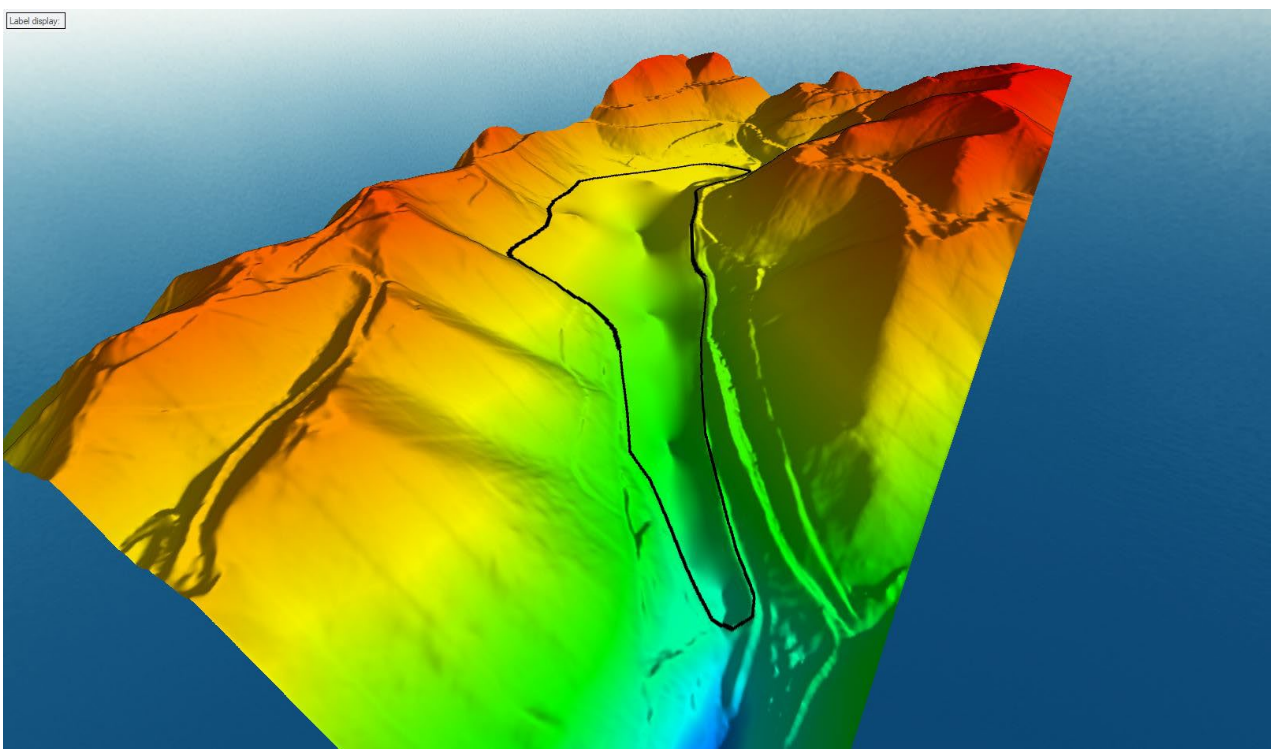
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	48	516.665633	-304.462926	
2	2	504	5424.98915	23874.05283	
3	3	42	452.082429	-335.82688	
4	4	1	10.763867	-3.382104	
5	5	1	10.763867	-3.229686	
6	6	4	43.055469	-24.063656	
				23203.08758	CF
				859.373614	CY

Unique ID: CBC_919221031

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

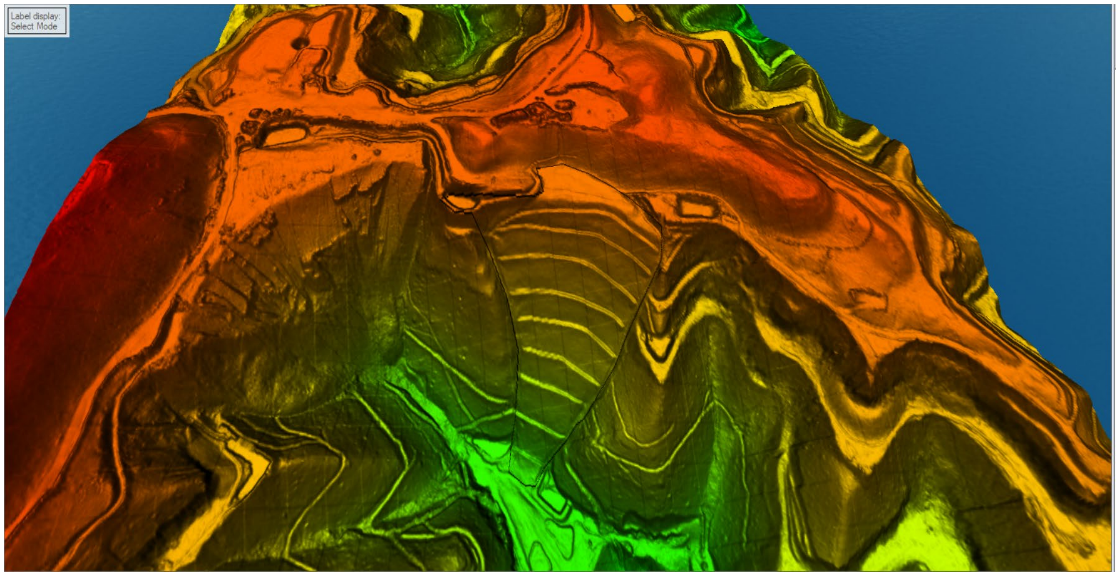
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	58325	627802.5638	17997542.13
2	2	1	10.763867	-0.46251
3	3	3	32.291602	-4.110031
4	4	1	10.763867	-1.610901
5	5	12	129.166408	-26.302624
6	6	1	10.763867	-2.110202
7	7	1	10.763867	-0.470394
8	8	2	21.527735	-4.393844
9	9	12	129.166408	-30.512516
10	10	1	10.763867	-0.543975
11	11	5	53.819337	-7.284531
12	12	1	10.763867	-0.903997
13	13	1	10.763867	-0.381045
14	14	83	893.400991	-394.363293
15	15	1	10.763867	1.038019
16	16	4	43.055469	-3.414953
17	17	10	107.638674	-26.285543
18	18	13	139.930276	-36.571133
19	19	1	10.763867	-0.767346
20	20	2	21.527735	-1.341542
21	21	11	118.402541	-18.785524
22	22	14	150.694143	-42.353821
23	23	1	10.763867	0.457254
24	24	11	118.402541	-17.966934
25	25	4	43.055469	-3.721103
26	26	1	10.763867	0
27	27	2	21.527735	-2.886745
28	28	1	10.763867	-0.155046
29	29	1	10.763867	-2.098376
30	30	2	21.527735	-4.709192
31	31	95	1022.567399	-674.939946
32	32	19	204.51348	-57.285533
33	33	3	32.291602	3.698765
34	34	4	43.055469	-13.081673
35	35	1	10.763867	-0.879032
36	36	2	21.527735	10.993808
37	37	6	64.583204	-9.369768
38	38	1	10.763867	-0.610986
39	39	1	10.763867	-0.445429
40	40	7	75.347072	-8.047935
41	41	1	10.763867	-3.378162
42	42	36	387.499225	-174.388579
43	43	2	21.527735	-1.221972
44	44	1	10.763867	0.723986
45	45	1	10.763867	1.182554
46	46	3	32.291602	-1.207519

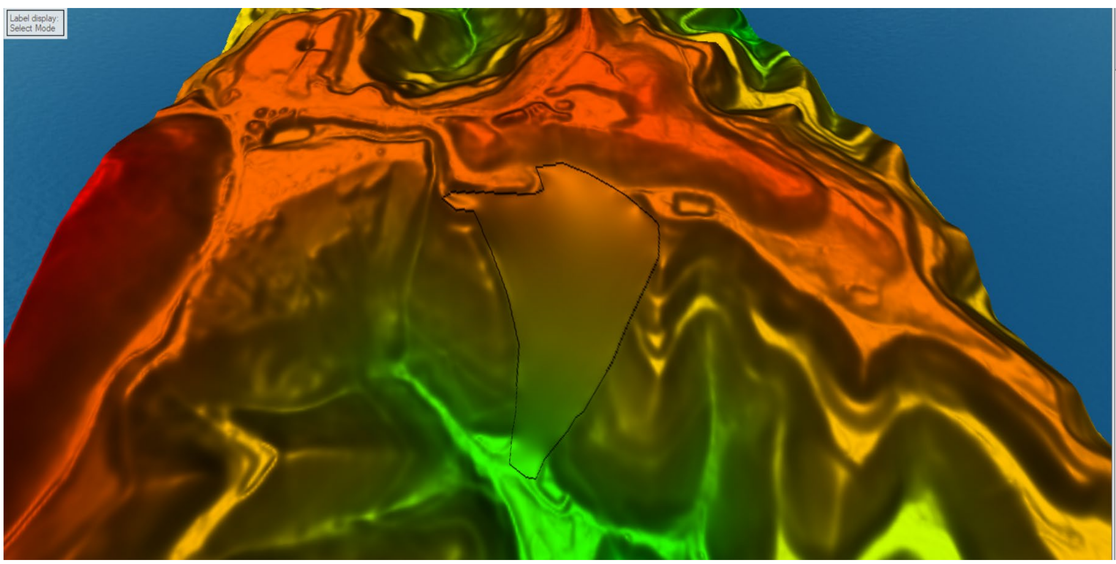
OBJECTID *	Value	Count	AREA	VOLUME	
47	47	11	118.402541	-29.968541	
48	48	1	10.763867	-0.00657	
49	49	2	21.527735	-5.033737	
50	50	3	32.291602	-4.456914	
51	51	137	1474.649828	-883.051017	
52	52	6	64.583204	21.682781	
53	53	1	10.763867	-5.676258	
54	54	2	21.527735	7.622216	
55	55	1	10.763867	-8.141226	
56	56	1	10.763867	-4.257194	
57	57	2	21.527735	-8.329121	
58	58	1	10.763867	-0.959183	
59	59	11	118.402541	-35.456904	
60	60	12	129.166408	-48.442659	
61	61	92	990.275797	-599.926618	
62	62	567	6103.112794	-14187.95448	
63	63	1	10.763867	1.985376	
64	64	8	86.110939	20.535703	
65	65	9	96.874806	-19.108755	
66	66	59	635.068174	-255.12284	
67	67	53	570.48497	-444.839944	
68	68	3	32.291602	-9.034711	
69	69	37	398.263092	-328.650093	
70	70	25	269.096684	-75.590152	
71	71	1	10.763867	-1.197007	
72	72	12	129.166408	-44.064582	
73	73	33	355.207623	-347.304222	
74	74	1	10.763867	-0.948671	
				17978685.16	CF
				665877.2283	CY

Unique ID: EBW_7122601

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

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5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

EBW_7122601

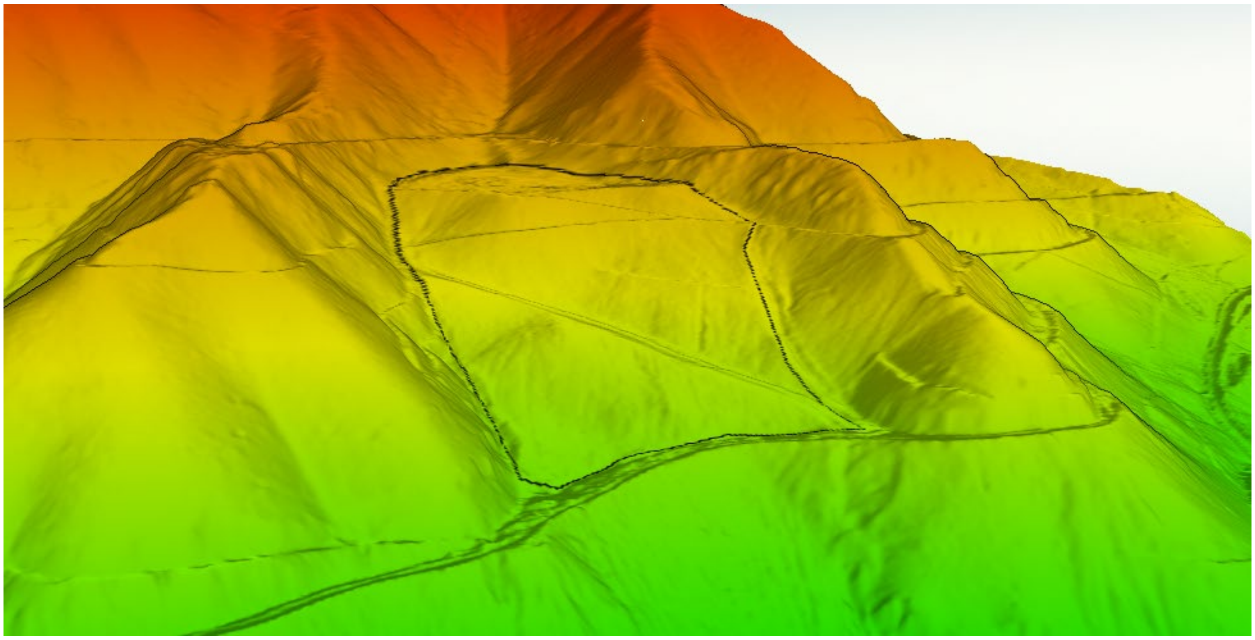
OBJECTID *	Value	Count	AREA	VOLUME
1	1	23	827.448092	4484.06284
2	2	607	21837.43443	-180744.621
3	3	15	539.64006	2168.941987
4	4	3	107.928012	601.842711
5	5	13	467.688052	2408.820074
6	6	1	35.976004	90.765631
7	7	1	35.976004	180.459711
8	8	2	71.952008	93.347893
9	9	4	143.904016	495.557159
10	10	1	35.976004	71.679729
11	11	10808	388828.6512	7249275.018
12	12	15	539.64006	1406.454473
13	13	1	35.976004	194.504055
14	14	13	467.688052	1164.433284
15	15	3	107.928012	-193.239273
16	16	16	575.616064	-1205.494763
17	17	1	35.976004	-74.367389
18	18	7	251.832028	633.44468
19	19	1	35.976004	-7.843401
20	20	2274	81809.4331	-770574.6013
21	21	1	35.976004	-20.087188
22	22	3	107.928012	-63.915376
23	23	3	107.928012	92.504706
24	24	55	1978.68022	-5002.412414
25	25	34	1223.184136	-2332.10757
26	26	28	1007.328112	-2487.025724
27	27	1	35.976004	131.528481
28	28	1	35.976004	-55.632815
29	29	2	71.952008	-54.183586
30	30	1	35.976004	-10.004069
31	31	1903	68462.33561	-657277.5616
32	32	2	71.952008	-57.011778
33	33	1	35.976004	72.074973
34	34	3	107.928012	196.489059
35	35	1	35.976004	-39.61225
36	36	3	107.928012	-209.646299
37	37	37	1331.112148	3006.332666
38	38	301	10828.7772	-209698.5939
39	39	6	215.856024	-330.116726
40	40	4	143.904016	79.892025
41	41	1	35.976004	-17.373178
42	42	1	35.976004	-12.480933
43	43	1	35.976004	8.458226
44	44	2	71.952008	-49.431873

EBW_7122601

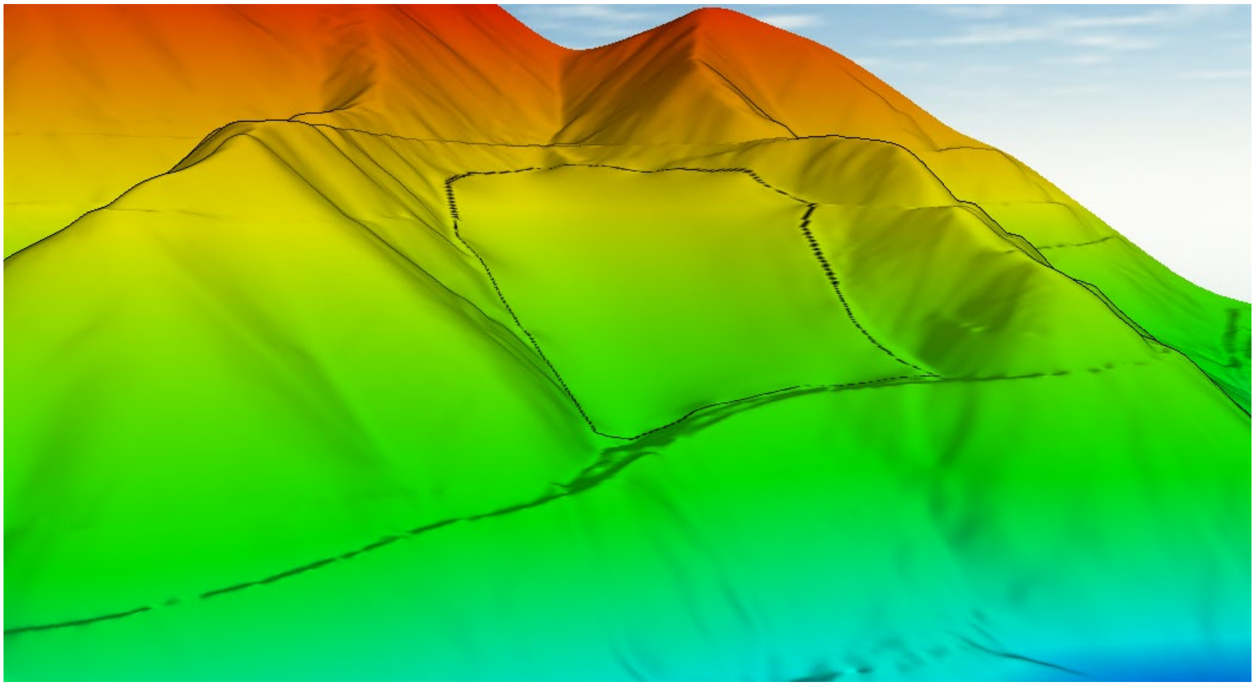
OBJECTID *	Value	Count	AREA	VOLUME
45	45	2	71.952008	98.846179
46	46	3	107.928012	203.814251
47	47	2	71.952008	-5.735432
48	48	1	35.976004	-34.377461
49	49	1	35.976004	-16.635389
50	50	147	5288.472588	18489.6064
51	51	3	107.928012	-107.769914
52	52	1	35.976004	-16.248928
53	53	2	71.952008	20.732753
54	54	59	2122.584236	-6563.433712
55	55	5	179.88002	110.018415
56	56	1	35.976004	30.530417
57	57	45	1618.92018	-20277.62521
58	58	1	35.976004	-2.907241
59	59	2	71.952008	43.94237
60	60	2	71.952008	-283.073885
61	61	44	1582.944176	-3527.642179
62	62	277	9965.353108	-57073.79603
63	63	1	35.976004	71.082471
64	64	1	35.976004	-11.822193
65	65	410	14750.16164	-66572.53263
66	66	79	2842.104316	-26354.95249
67	67	1	35.976004	0
68	68	2	71.952008	248.634942
69	69	1	35.976004	3.987575
70	70	1	35.976004	-2.353899
71	71	1	35.976004	-10.979005
72	72	4	143.904016	-82.122958
73	73	38	1367.088152	-1627.352056
74	74	2	71.952008	-6.736718
75	75	1	35.976004	-15.757068
76	76	3	107.928012	-142.823682
77	77	1	35.976004	-19.138602
78	78	2	71.952008	-32.735002
			CF	**5272871.892**
			CY	**195291.6**

Unique ID: EBW_71422229A

Current Surface:



Historical Surface:



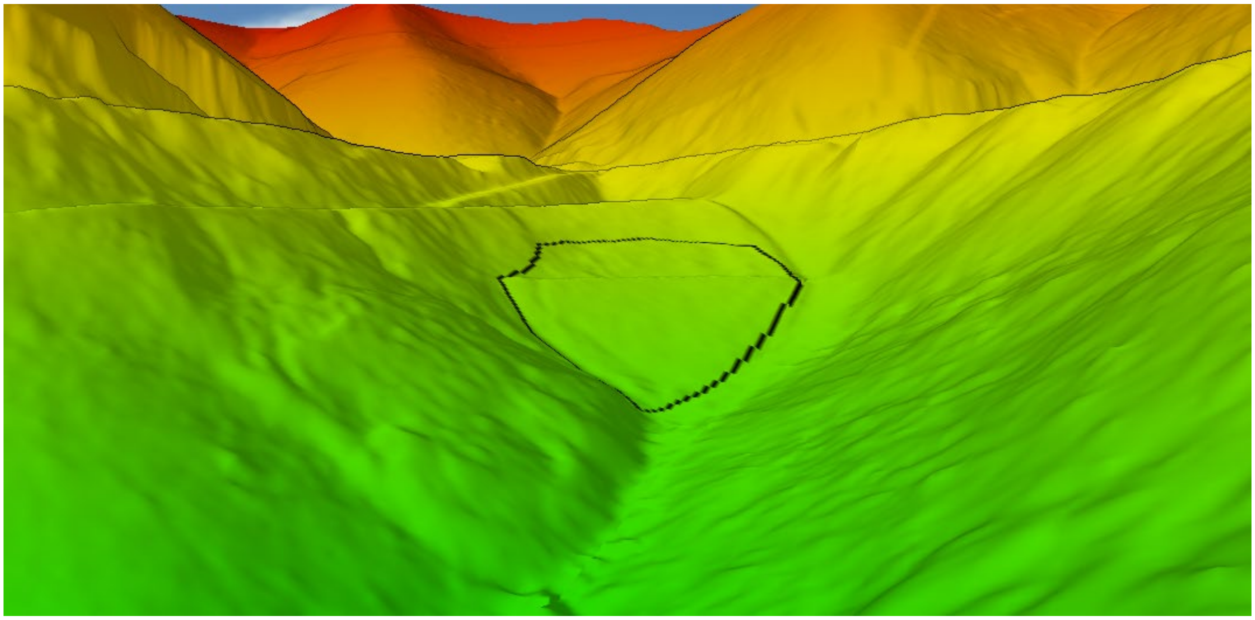
Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

Rowid	VALUE	COUNT	AREA	VOLUME
0	1	4	64	-23.554688
1	2	20492	327872	5357323.777
2	3	6	96	-41.201172
3	4	1	16	-0.119141
4	5	2	32	-3.882813
5	6	1	16	-0.417969
6	7	8	128	-29.580078
7	8	1	16	-1.257813
8	9	2	32	-0.455078
9	10	3	48	-9.666016
10	11	76	1216	-840.474609
11	12	8	128	58.845703
12	13	3	48	-14.136719
13	14	3	48	-18.365234
14	15	1	16	-14.279297
15	16	10	160	-237.283203
16	17	4	64	-15.597656
17	18	3	48	-6.951172
18	19	2	32	-9.794922
19	20	8	128	-49.898438
20	21	4	64	-13.472656
21	22	8	128	-36.808594
22	23	1	16	-0.611328
23	24	4	64	-21.191406
24	25	1	16	-10.693359
25	26	2	32	-3.736328
26	27	1	16	-2.197266
27	28	1	16	-0.255859
28	29	2	32	-8.195313
29	30	2	32	-5.738281
30	31	18	288	-120.554688
31	32	1	16	-0.023438
32	33	111	1776	-1120.824219
33	34	10	160	24.826172
34	35	7	112	-43.818359
35	36	1	16	3.078125
36	37	16	256	-149.546875
37	38	1	16	-2.503906
38	39	2	32	-5.800781
39	40	10	160	-87.794922
40	41	2	32	-9.738281
41	42	1	16	-1.384766
42	43	1	16	-6.097656
43	44	7	112	-64.214844
44	45	1	16	-1.246094
45	46	1	16	-0.236328

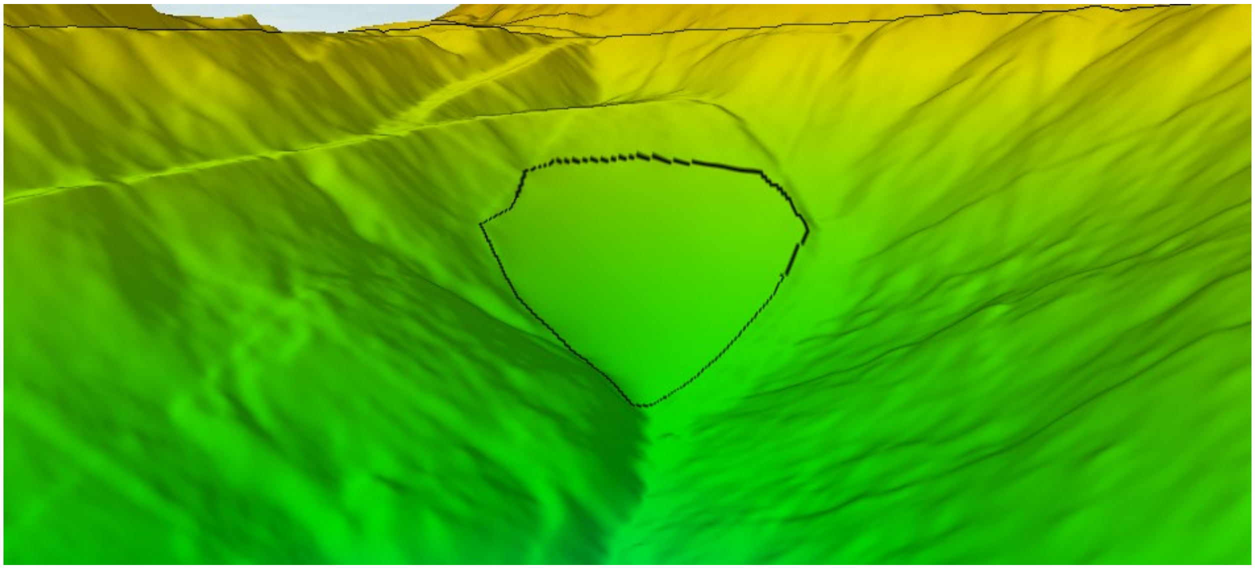
Rowid	VALUE	COUNT	AREA	VOLUME	
46	47	3	48	-21.107422	
47	48	1	16	-5.519531	
48	49	15	240	-212.839844	
49	50	1	16	-1.605469	
				5354135.854	CF
				198301	CY

Unique ID: EBW_71422229B

Current Surface:



Historical Surface:

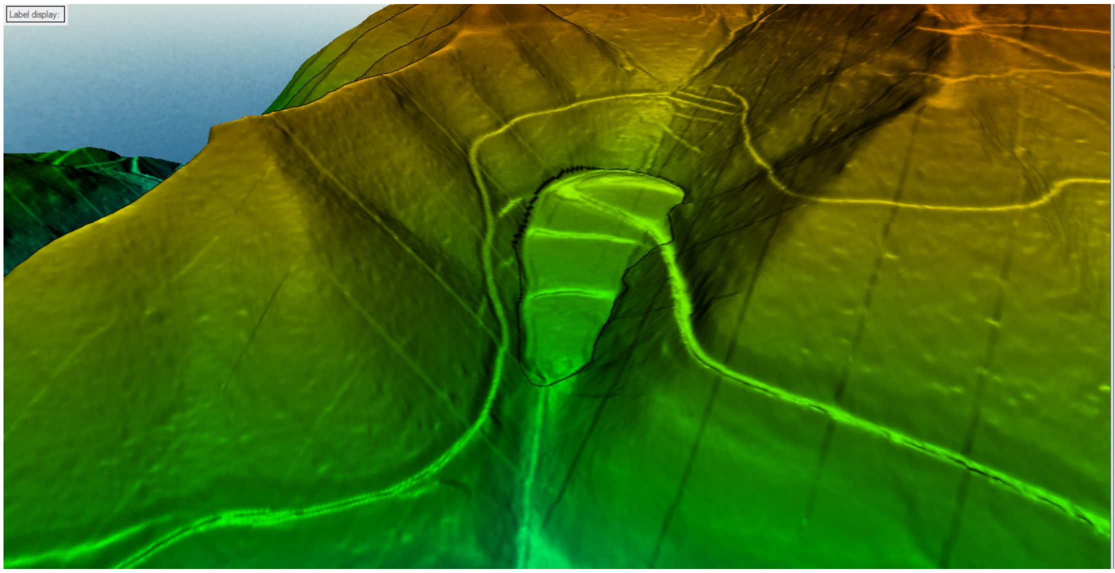


Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

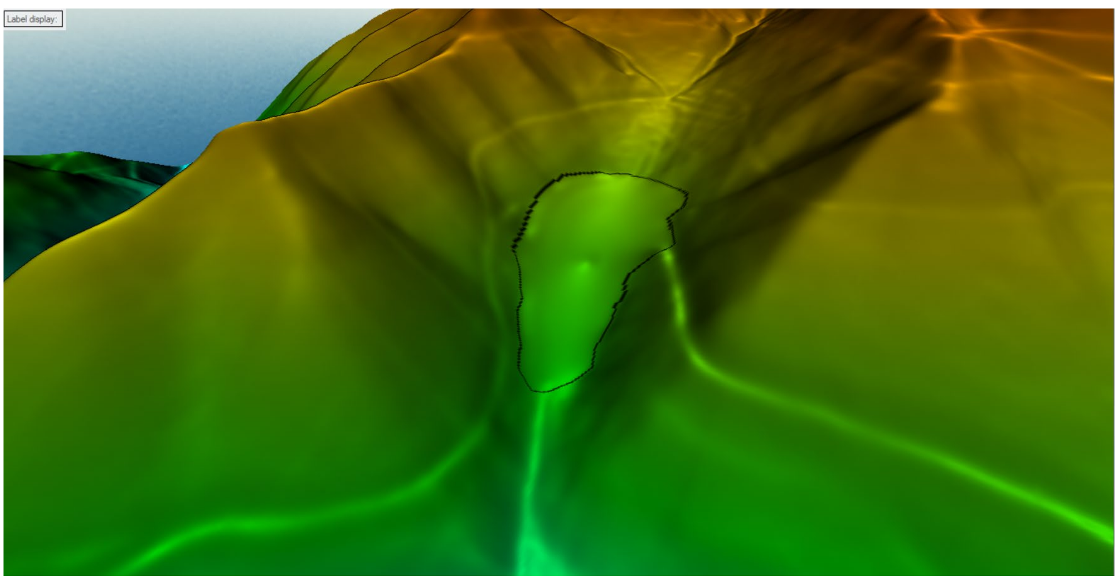
Rowid	VALUE	COUNT	AREA	VOLUME
0	1	1927	20741.9724	83549.0767
1	2	1	10.763867	-2.688339
2	3	1	10.763867	-0.892171
3	4	15	161.45801	-73.879391
4	5	2	21.527735	-0.5558
5	6	256	2755.55004	-1491.1872
6	7	1	10.763867	1.534692
7	8	1	10.763867	-5.225574
8	9	2	21.527735	-0.86195
9	10	1	10.763867	-0.785741
10	11	15	161.45801	-41.842695
11	12	6	64.583204	5.945618
12	13	5	53.819337	9.800743
13	14	3	32.291602	1.772517
14	15	3	32.291602	0.566312
15	16	1	10.763867	-0.441487
16	17	1	10.763867	-1.027508
17	18	1	10.763867	1.160217
18	19	1	10.763867	-0.643835
19	20	1	10.763867	-0.646463
20	21	4	43.055469	-38.409347
21	22	2	21.527735	-2.935361
22	23	2	21.527735	-7.242485
23	24	2	21.527735	-3.685626
24	25	1	10.763867	-1.712075
25	26	1	10.763867	-1.001229
				81894.1925 CF
				3033 CY

Unique ID: EBW_72122735

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

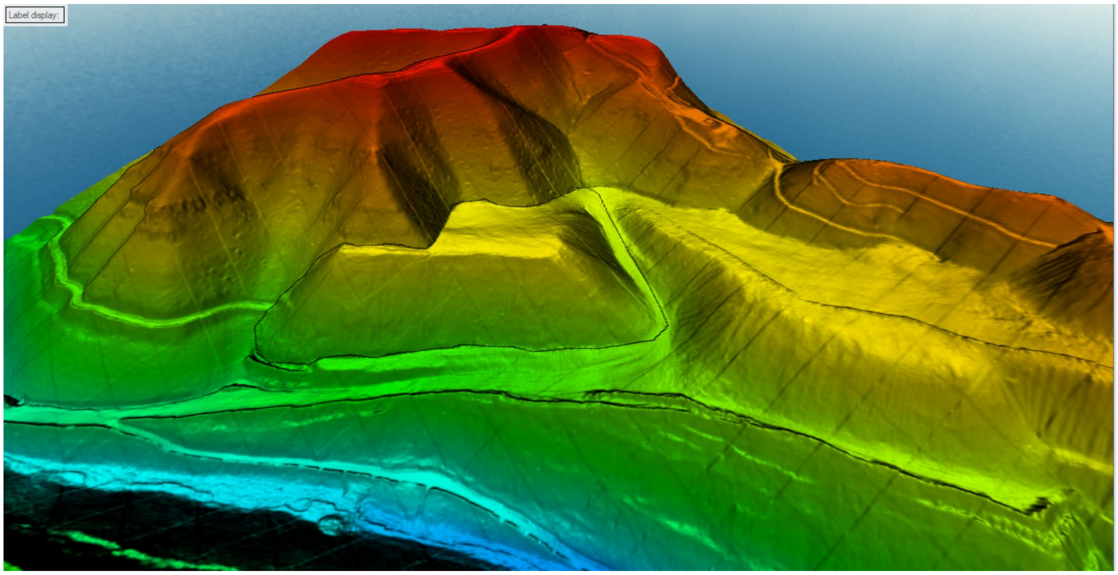
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

EBW_72122735

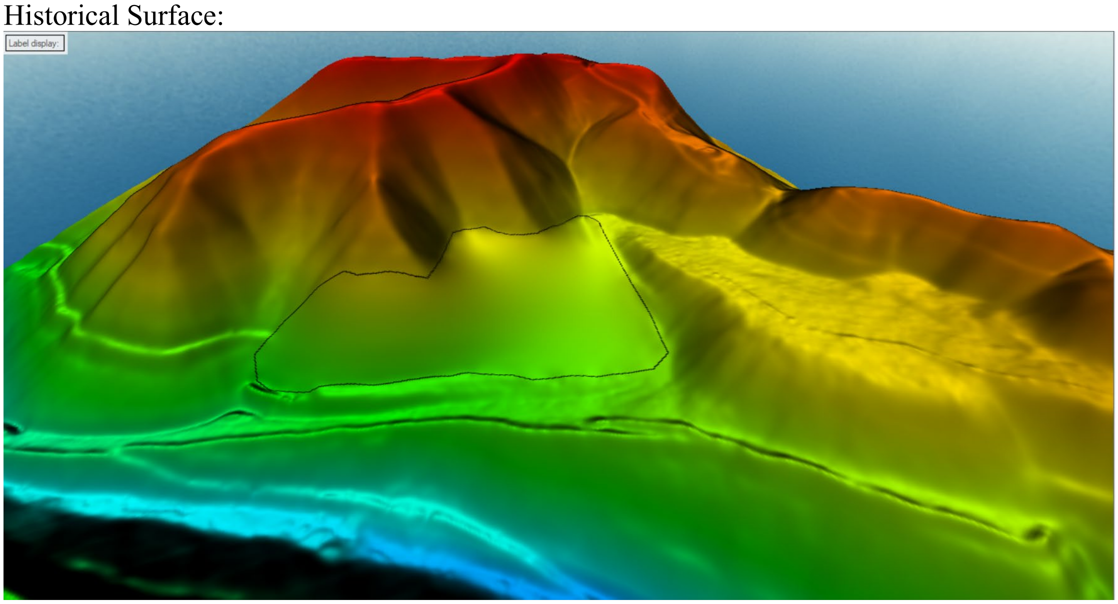
OBJECTID *	Value	Count	AREA	VOLUME
1	1	1004	22652.75	-67937.67053
2	2	5	112.8125	83.488411
3	3	1	22.5625	2.599976
4	4	24	541.5	325.578087
5	5	1	22.5625	1.479012
6	6	2	45.125	6.02346
7	7	1	22.5625	2.754211
8	8	2868	64709.25	789097.7738
9	9	1	22.5625	0.085381
10	10	1	22.5625	-1.996803
11	11	1	22.5625	-7.16095
12	12	2	45.125	19.491554
13	13	151	3406.9375	-5740.258598
			CF	**715852.187**
			CY	**26513.04396**

Unique ID: EBW_72222302

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

EBW_72222302

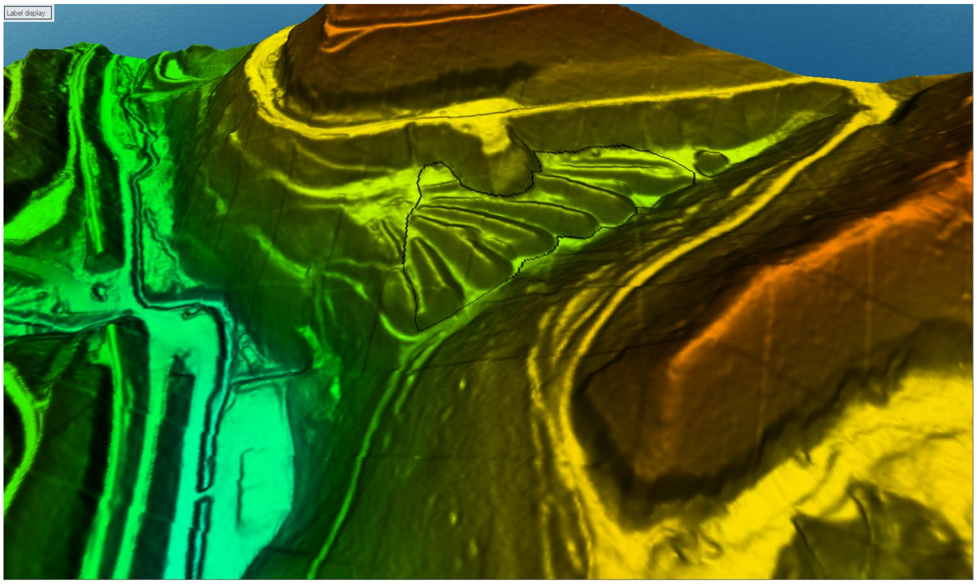
OBJECTID *	Value	Count	AREA	VOLUME
1	1	1	36	-2.307129
2	2	12462	448632	13191930.5
3	3	1	36	-5.405273
4	4	2	72	-51.358887
5	5	1	36	-58.412109
6	6	1	36	-7.03125
7	7	2	72	-90.808594
8	8	8	288	-225.004395
9	9	1	36	-0.791016
10	10	44	1584	-1760.40527
11	11	9	324	-84.062988
12	12	13	468	-155.772949
13	13	4	144	-56.808105
14	14	1	36	-3.098145
15	15	132	4752	-6838.05762
16	16	2	72	-5.102051
17	17	7	252	-117.874512
18	18	2	72	-41.690918
19	19	2	72	-10.023926
20	20	2	72	-19.656738
21	21	1	36	-5.422852
22	22	1	36	-2.126953
23	23	2	72	-43.677246
24	24	5	180	-31.091309
25	25	1	36	-13.456055
26	26	1	36	-6.609375
27	27	7	252	-77.972168
28	28	1	36	-6.00293
29	29	1	36	0
30	30	1	36	-31.728516
31	31	17	612	-897.077637
32	32	1	36	-26.811035
33	33	1	36	-13.07373
34	34	1	36	-23.519531
35	35	7	252	-183.9375
36	36	5	180	-183.27832
37	37	1	36	-31.570313
38	38	4	144	-46.388672
39	39	5	180	-144.729492
40	40	21	756	-1071.3252
41	41	13	468	-696.550781
42	42	1	36	-39.440918
43	43	5	180	-106.672852
44	44	3	108	-86.668945

EBW_72222302

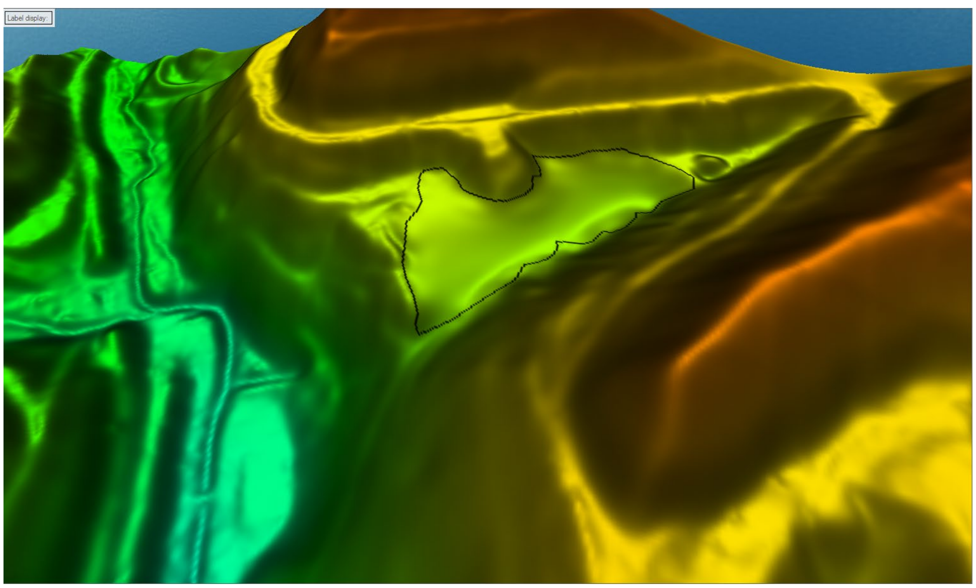
OBJECTID *	Value	Count	AREA	VOLUME
45	45	3	108	-102.60791
46	46	10	360	-135.166992
47	47	9	324	-110.8125
48	48	6	216	-153.18457
49	49	3	108	30.691406
50	50	2	72	-41.167969
51	51	1	36	-5.049316
			CF	**13178110.4**
			CY	**488078.164**

Unique ID: EBW_72722411

Current Surface:



Historical Surface:



Process Documentation:

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5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

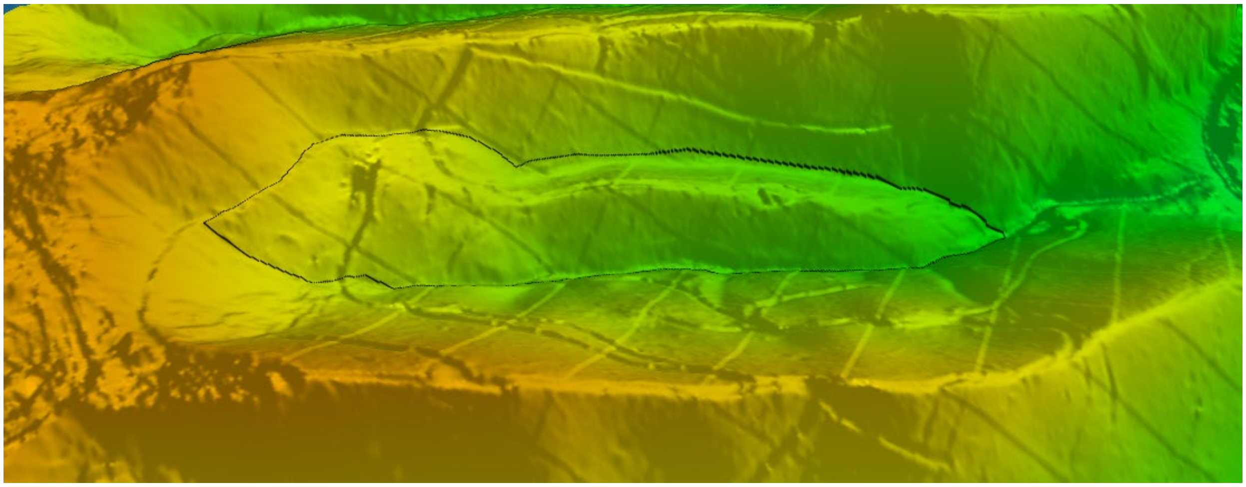
EBW_72722411

OBJECTID *	Value	Count	AREA	VOLUME
1	1	62	6324.62	-8925.551238
2	2	10	1020.1	1544.445347
3	3	757	77221.57	684312.1314
4	4	1	102.01	207.369694
5	5	11	1122.11	-1367.683634
6	6	1	102.01	37.319821
7	7	14	1428.14	-2597.631354
8	8	2	204.02	-160.075507
9	9	15	1530.15	-3571.732216
10	10	1	102.01	-44.791256
11	11	27	2754.27	-3691.897804
12	12	7	714.07	-643.365315
13	13	1	102.01	-38.353369
14	14	2	204.02	-23.684451
15	15	2	204.02	-182.689052
16	16	1	102.01	-47.493425
17	17	6	612.06	-1221.841212
18	18	5	510.05	-1713.698267
19	19	13	1326.13	-2539.565847
20	20	4	408.04	-1135.284631

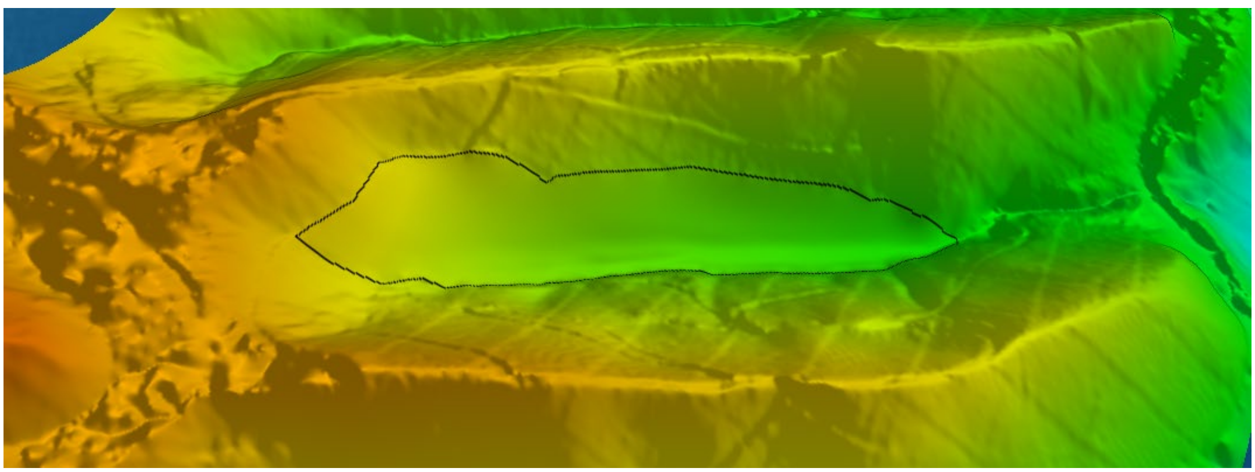
CF	**658195.9277**
CY	**24377.62695**

Unique ID: EBW_72722615

Current Surface:



Historical Surface:



Process Documentation:
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4: Create new grid using the trimmed contours.
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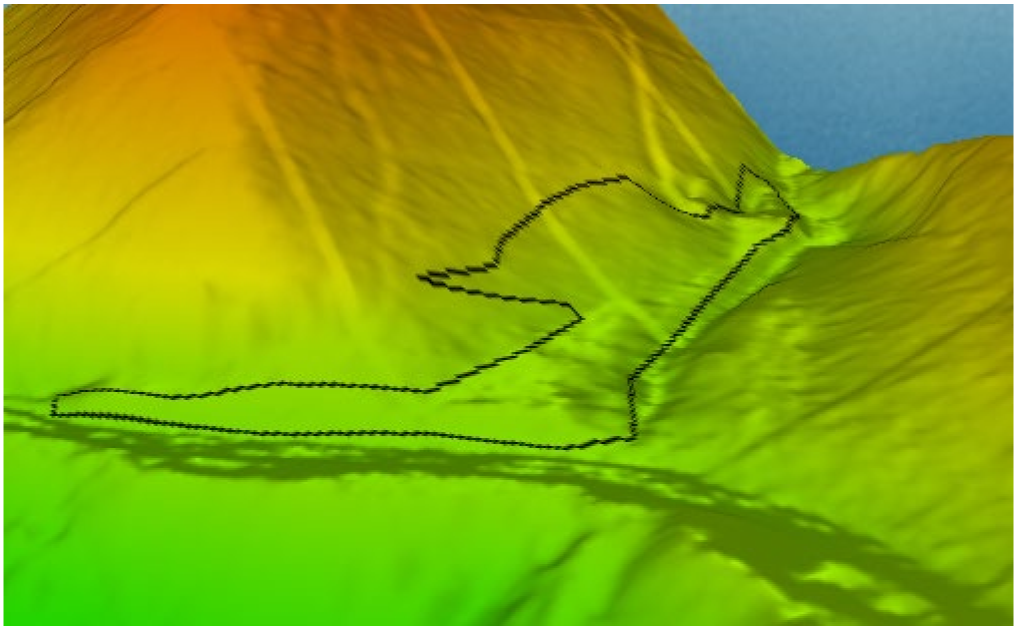
Rowid	VALUE	COUNT	AREA	VOLUME
0	1	107	1151.73381	-1091.8572
1	2	13635	146765.331	2425268.86
2	3	15	161.45801	-57.188301
3	4	2	21.527735	-1.210147
4	5	1	10.763867	-0.607044
5	6	2	21.527735	-3.744754
6	7	23	247.568949	-151.8675
7	8	4	43.055469	-6.425209
8	9	11	118.402541	-45.318089
9	10	4	43.055469	-24.298852
10	11	1	10.763867	-1.11817
11	12	34	365.97149	-268.75506
12	13	1	10.763867	-4.090322
13	14	1	10.763867	-8.133342
14	15	1	10.763867	-1.370448
15	16	1	10.763867	-5.102063
16	17	2	21.527735	6.172931
17	18	137	1474.64983	-1469.8132
18	19	1	10.763867	-0.914508
19	20	1	10.763867	-0.578137
20	21	1	10.763867	-0.693765
21	22	1	10.763867	-1.285042
22	23	16	172.221878	-94.312606
23	24	2	21.527735	-2.031365
24	25	1	10.763867	-2.383503
25	26	12	129.166408	-55.468342
26	27	1	10.763867	-3.566057
27	28	8	86.110939	-12.069932
28	29	42	452.082429	-243.82025
29	30	52	559.721103	-215.93301
30	31	1	10.763867	0.454626
31	32	136	1463.88596	-1382.0099
32	33	2	21.527735	1.386216
33	34	7	75.347072	-32.120789
34	35	1	10.763867	0.530835
35	36	25	269.096684	-164.13058
36	37	1	10.763867	2.078667
37	38	1	10.763867	-0.036791
38	39	20	215.277347	-135.3735
39	40	10	107.638674	-48.408496
40	41	3	32.291602	-16.763357
41	42	1	10.763867	-1.114228
42	43	1	10.763867	-0.257534
43	44	5	53.819337	-10.750728
44	45	8	86.110939	-42.146217
45	46	1	10.763867	-2.047132

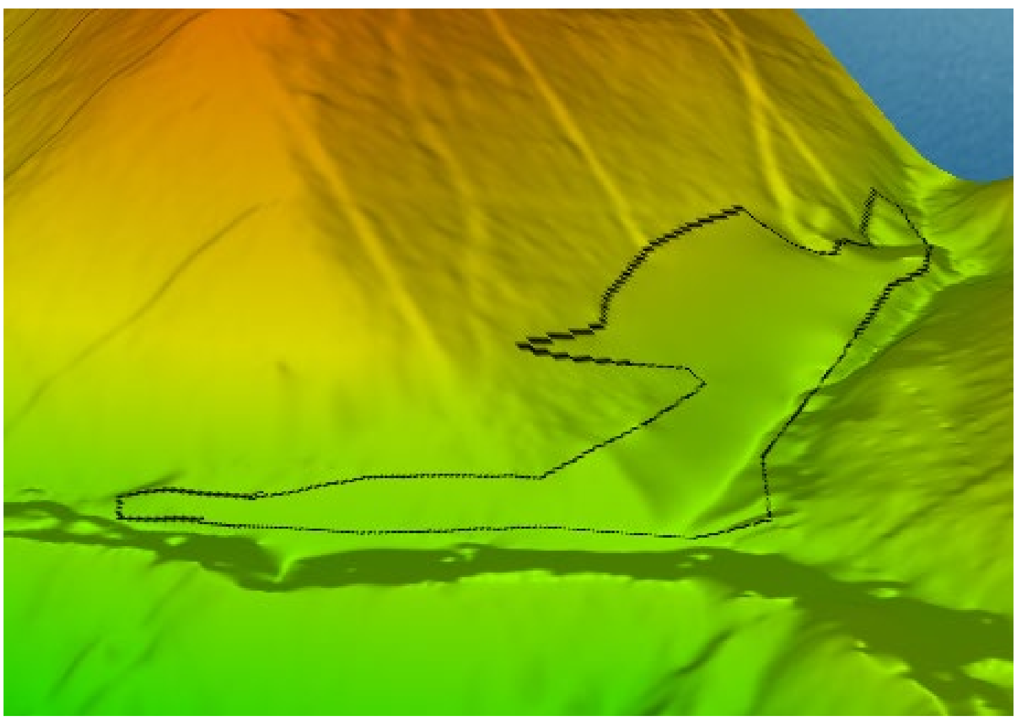
Rowid	VALUE	COUNT	AREA	VOLUME	
46	47	1	10.763867	-0.115627	
47	48	16	172.221878	-158.86165	
48	49	1	10.763867	-4.089008	
49	50	11	118.402541	-90.549457	
50	51	1	10.763867	-5.602677	
51	52	5	53.819337	-50.55286	
52	53	12	129.166408	-58.586343	
53	54	367	3950.33932	-7024.4772	
54	55	143	1539.23303	-1849.3328	
55	56	21	226.041215	97.221689	
56	57	1	10.763867	1.495274	
57	58	2	21.527735	-23.067683	
58	59	18	193.749613	-169.65442	
59	60	2	21.527735	-7.62353	
60	61	13	139.930276	-83.645971	
				2410242.93	CF
				89268	CY

Unique ID: EBW_72722628

Current Surface:



Historical Surface:



Process Documentation:
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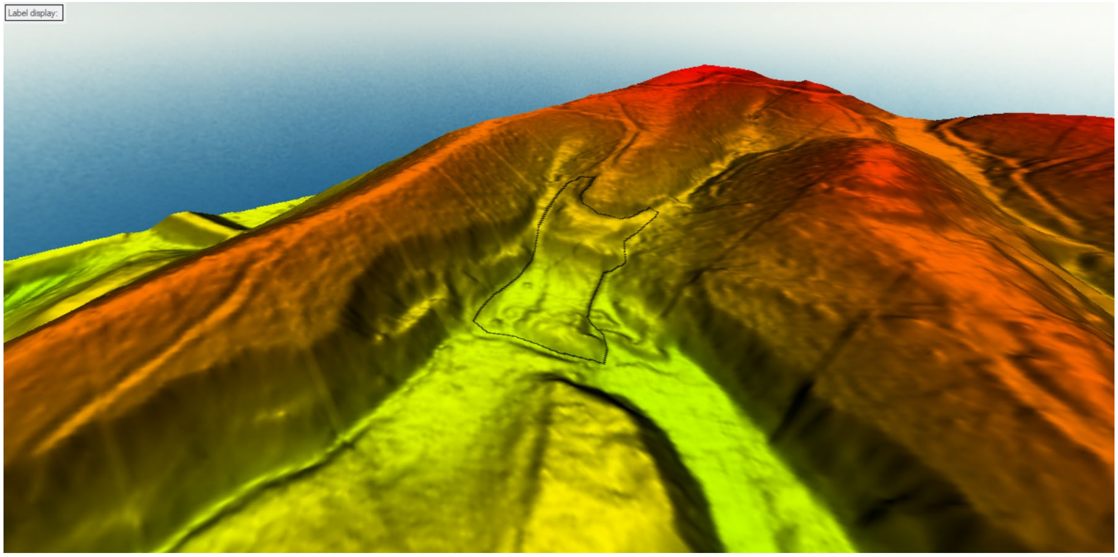
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

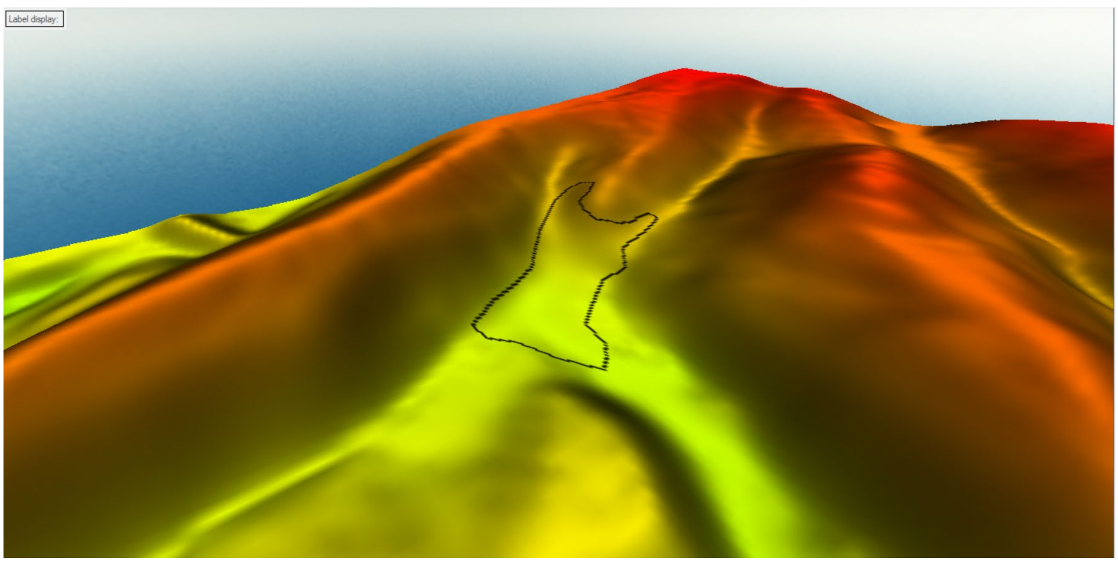
Rowid	VALUE	COUNT	AREA	VOLUME	
0	1	1	10.763867	-0.529521	
1	2	1	10.763867	-0.503242	
2	3	1782	19181.212	28487.165	
3	4	2	21.527735	-11.294703	
4	5	3	32.291602	-7.765437	
5	6	94	1011.8035	-459.69939	
6	7	2	21.527735	9.692999	
7	8	1	10.763867	0.111686	
8	9	1	10.763867	-0.674056	
9	10	3	32.291602	-10.687658	
10	11	2	21.527735	-3.443859	
11	12	209	2249.6483	-2044.353	
12	13	1	10.763867	-0.374475	
13	14	1	10.763867	-0.373161	
14	15	122	1313.1918	1173.7674	
15	16	1	10.763867	-1.645064	
16	17	3	32.291602	-1.729156	
17	18	1	10.763867	-0.118255	
18	19	1	10.763867	0.409952	
19	20	19	204.51348	-105.1264	
20	21	12	129.16641	96.468796	
				27119.298	CF
				1004	CY

Unique ID: EBW_81122349

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create new grid using the trimmed contours.

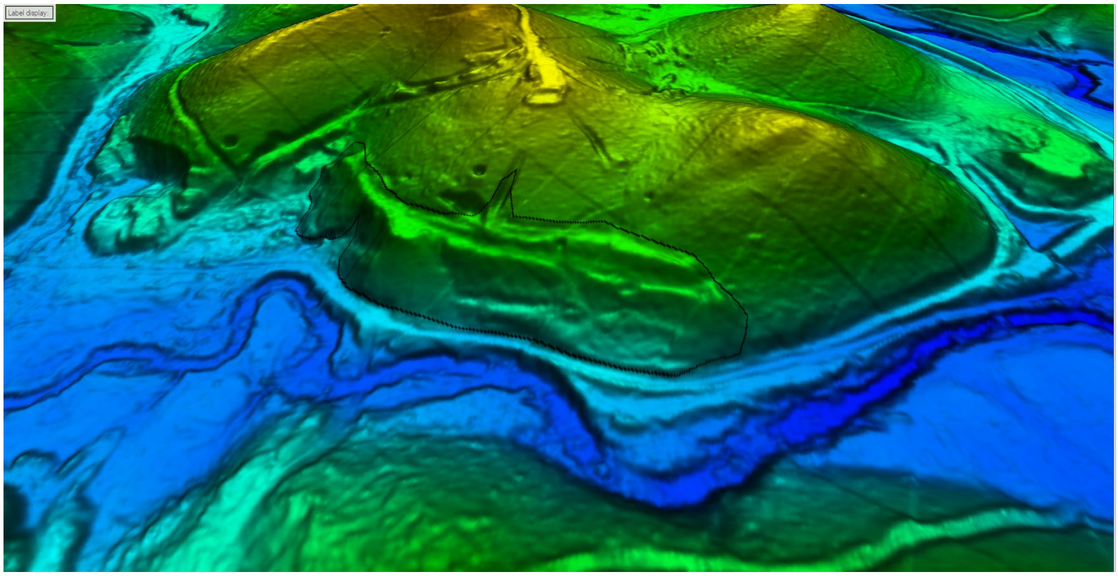
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

EBW_81122349

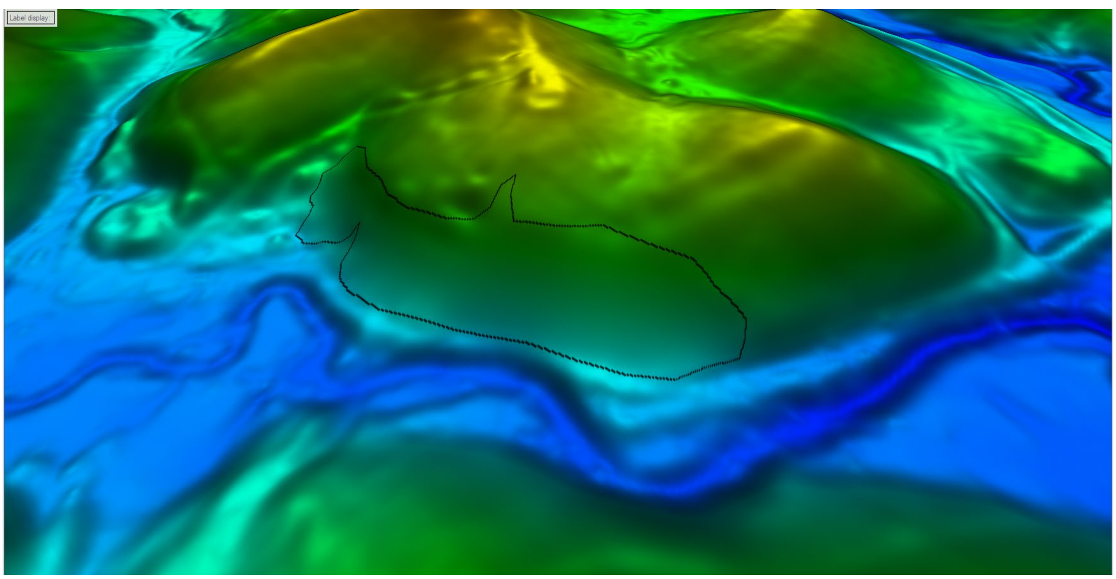
OBJECTID *	Value	Count	AREA	VOLUME
1	1	13	844.050467	-1095.8
2	2	30	1947.808771	-1873.93
3	3	4	259.707836	128.3005
4	4	3	194.780877	95.7102
5	5	2	129.853918	-98.2781
6	6	308	19997.50338	66454.68
7	7	3	194.780877	-75.7851
8	8	2	129.853918	-62.6285
9	9	1	64.926959	-62.0262
10	10	1	64.926959	-18.2132
11	11	1	64.926959	-9.92292
12	12	2	129.853918	43.49599
13	13	49	3181.420993	-3192.6
			CF	**60233.01**
			CY	**2230.852**

Unique ID: EBW_81522126

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create new grid using the trimmed contours.

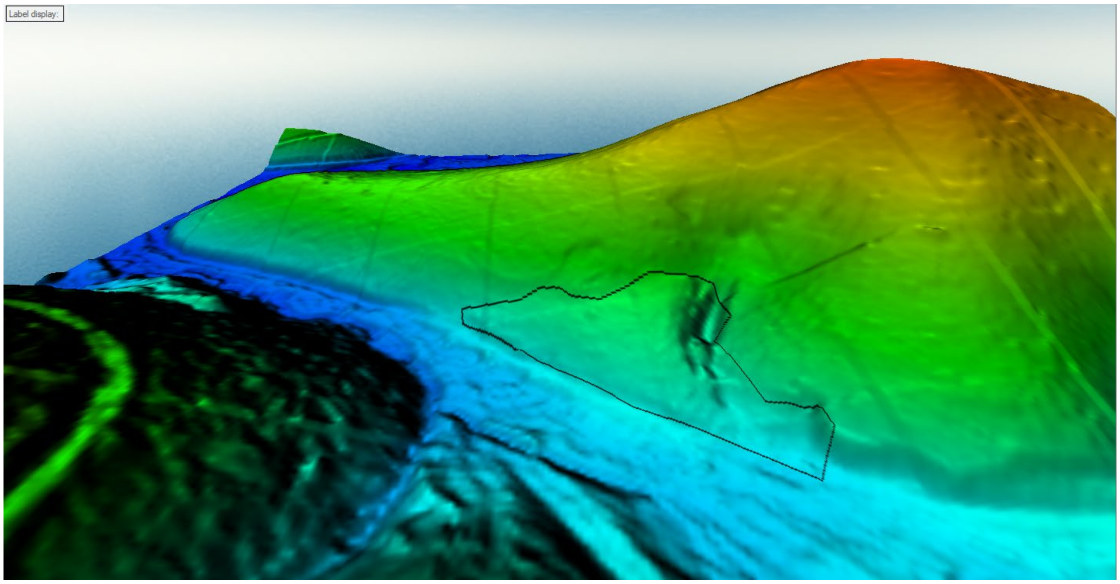
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

EBW_81522126

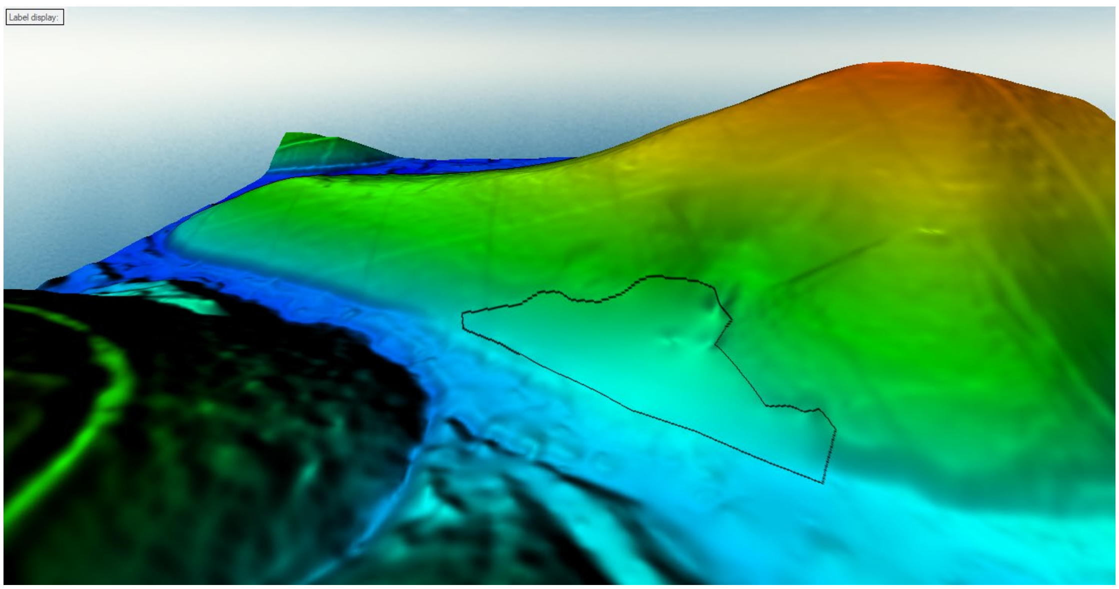
OBJECTID *	Value	Count	AREA	VOLUME
1	1	2864	81974.84	499943.6
2	2	2	57.245	-25.0377
3	3	1	28.6225	-8.1549
4	4	1	28.6225	-11.551
5	5	1	28.6225	-0.02795
6	6	1	28.6225	-7.12767
7	7	2	57.245	-3.19697
8	8	1	28.6225	-40.2364
9	9	1	28.6225	-13.0325
10	10	1	28.6225	-8.50429
11	11	1	28.6225	-22.8749
12	12	1	28.6225	-8.71393
13	13	5	143.1125	-35.841
14	14	1	28.6225	-4.36745
15	15	1	28.6225	-0.06289
16	16	1	28.6225	-3.90625
17	17	32	915.92	-2272.09
18	18	3	85.8675	-77.6148
19	19	1	28.6225	11.57199
20	20	3	85.8675	31.5155
21	21	2	57.245	-24.5555
22	22	6	171.735	-47.2593
23	23	1	28.6225	-5.86286
24	24	2	57.245	-4.2766
25	25	5	143.1125	-75.5114
26	26	1	28.6225	-4.70636
27	27	31	887.2975	-411.609
28	28	1	28.6225	-14.0457
29	29	3	85.8675	38.36365
30	30	4	114.49	-81.8739
31	31	2	57.245	-11.4252
32	32	1	28.6225	-0.86301
			CF	496800.8
			CY	18400.03

Unique ID: EBW_81522541

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

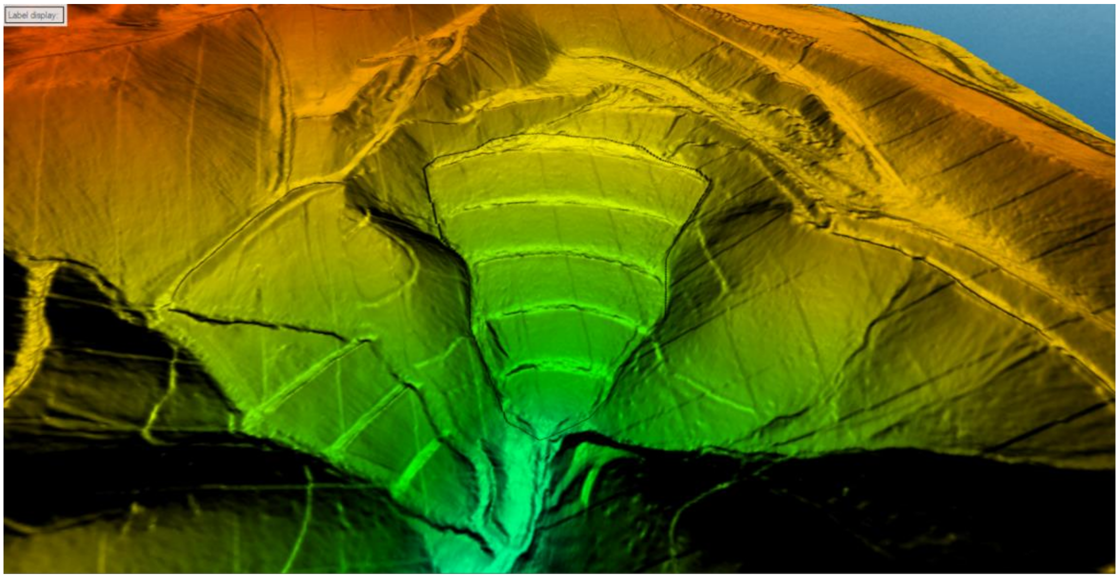
6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

EBW_81522541

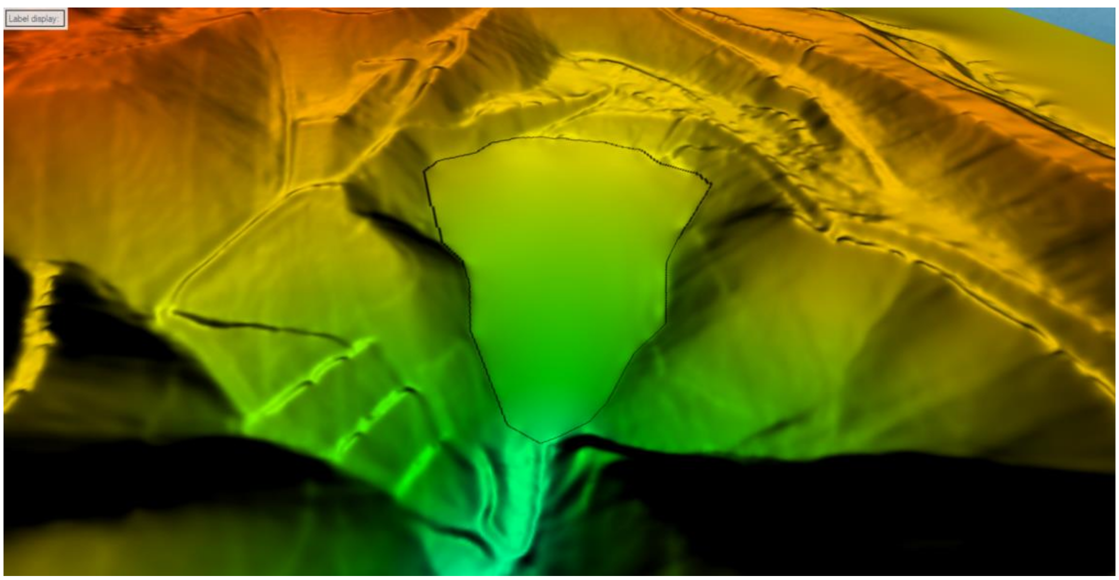
OBJECTID *	Value	Count	AREA	VOLUME
1	1	6	64.583204	83.57239
2	2	264	2841.660983	-2711.01
3	3	7	75.347072	15.05522
4	4	1	10.763867	-1.44534
5	5	2	21.527735	1.277158
6	6	95	1022.567399	-1873.14
7	7	6	64.583204	35.4845
8	8	3	32.291602	16.21675
9	9	1	10.763867	1.2246
10	10	1	10.763867	1.434832
11	11	2	21.527735	2.601618
12	12	1536	16533.30027	50835.31
13	13	1	10.763867	3.460941
14	14	1	10.763867	0.060442
15	15	13	139.930276	-19.7986
16	16	1	10.763867	-1.469
17	17	2	21.527735	-1.63192
18	18	1	10.763867	2.115457
19	19	1	10.763867	-1.29555
20	20	8	86.110939	-12.6402
21	21	15	161.45801	-58.0424
22	22	25	269.096684	-83.0915
23	23	2	21.527735	1.468995
24	24	4	43.055469	-4.92994
25	25	1	10.763867	-2.94325
26	26	1	10.763867	-2.37299
27	27	1	10.763867	-0.16556
28	28	2	21.527735	-2.4019
29	29	1	10.763867	-1.26927
30	30	1	10.763867	-5.06921
31	31	1	10.763867	-1.38753
32	32	1	10.763867	-3.66592
33	33	1	10.763867	-3.99703
			CF	46207.52
			CY	1711.39

Unique ID: EBW_808221249A

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

EBW_808221249(A)

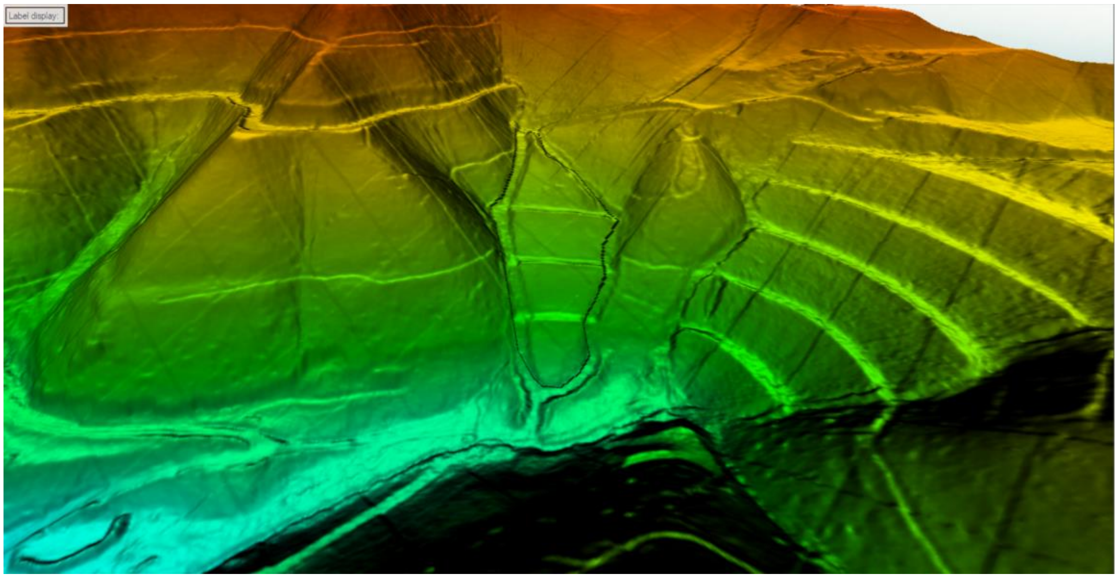
OBJECTID *	Value	Count	AREA	VOLUME
1	1	10	202.5	-178.28009
2	2	7317	148169.25	1053064.574
3	3	10	202.5	-194.003998
4	4	1	20.25	-3.206085
5	5	2	40.5	-10.649048
6	6	2	40.5	-17.014252
7	7	3	60.75	-38.922913
8	8	2	40.5	-30.011627
9	9	2	40.5	-23.915863
10	10	1	20.25	-1.688324
11	11	1	20.25	-4.046539
12	12	2	40.5	-11.511749
13	13	7	141.75	-36.233459
14	14	3	60.75	-16.388855
15	15	1	20.25	-7.96701
16	16	243	4920.75	-6432.027374
17	17	6	121.5	-24.009796
18	18	2	40.5	-5.952393
19	19	2	40.5	-5.102051
20	20	1	20.25	5.198456
21	21	3	60.75	-20.729553
22	22	1	20.25	-11.43512
23	23	3	60.75	29.853424
24	24	2	40.5	-4.301147
25	25	1	20.25	1.235962
26	26	1	20.25	-2.491699
27	27	2	40.5	17.71875
28	28	2	40.5	21.47113
29	29	1	20.25	-1.858887
30	30	3591	72717.75	-180499.5862
31	31	4	81	54.686371
32	32	2	40.5	-30.721069
33	33	1	20.25	5.514862
34	34	21	425.25	-602.212555
35	35	1906	38596.5	192673.7295
36	36	1	20.25	-3.077545
37	37	10	202.5	-166.303619
38	38	1	20.25	-2.405182
39	39	1	20.25	-1.856415
40	40	2	40.5	-1.675964
41	41	1	20.25	-3.460693
42	42	1	20.25	-4.622498
43	43	1	20.25	-1.16922
44	44	1	20.25	-3.272827
45	45	1	20.25	-1.31012
46	46	2	40.5	12.245911
47	47	1	20.25	2.101135
48	48	2	40.5	-8.940948
49	49	3	60.75	-20.259888

EBW_808221249(A)

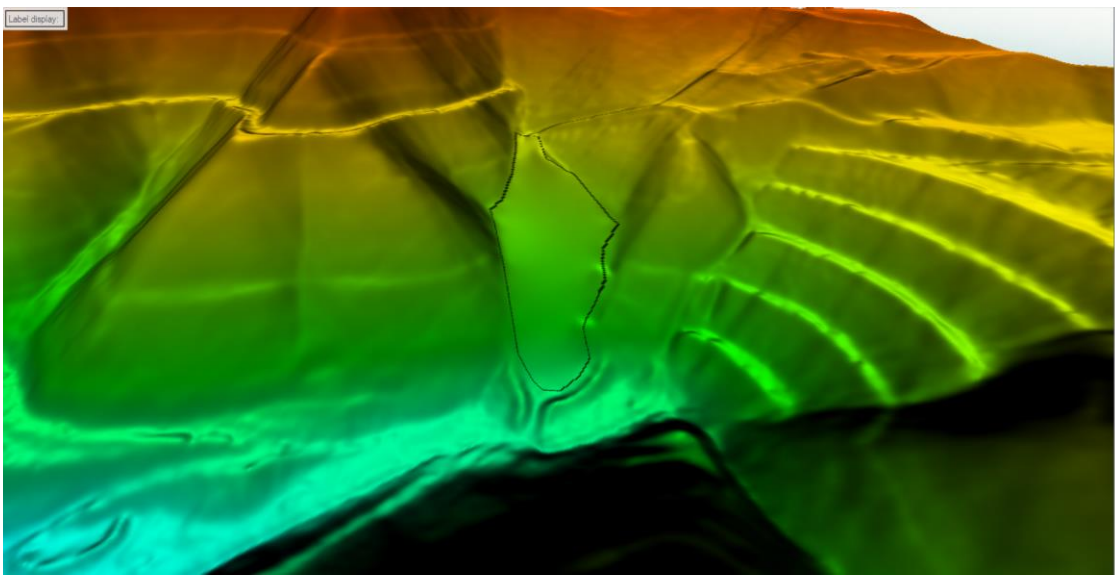
OBJECTID *	Value	Count	AREA	VOLUME
50	50	1	20.25	4.081146
51	51	3	60.75	8.889038
52	52	1	20.25	0.486969
53	53	2	40.5	4.733734
54	54	1	20.25	0.860229
55	55	863	17475.75	68051.78861
56	56	2	40.5	7.907684
57	57	2	40.5	1.628998
58	58	2	40.5	18.803925
59	59	82	1660.5	2480.071289
60	60	1	20.25	-5.838684
61	61	2	40.5	9.526794
62	62	1	20.25	-1.060455
63	63	827	16746.75	71096.05673
64	64	2	40.5	15.49649
65	65	1	20.25	0.19281
66	66	1	20.25	3.262939
67	67	33	668.25	586.80011
68	68	2	40.5	-14.485474
69	69	1	20.25	4.006989
70	70	1	20.25	-11.103882
71	71	4	81	19.891571
72	72	3	60.75	-14.745026
73	73	1	20.25	-3.895752
74	74	2	40.5	16.045258
75	75	3	60.75	-16.289978
76	76	1	20.25	0
77	77	2	40.5	0.479553
78	78	1	20.25	2.484283
79	79	1	20.25	-10.883881
80	80	3	60.75	14.349518
			CF	**1199725.249**
			CY	**44434.26848**

Unique ID: EBW_808221249B

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create new grid using the trimmed contours.

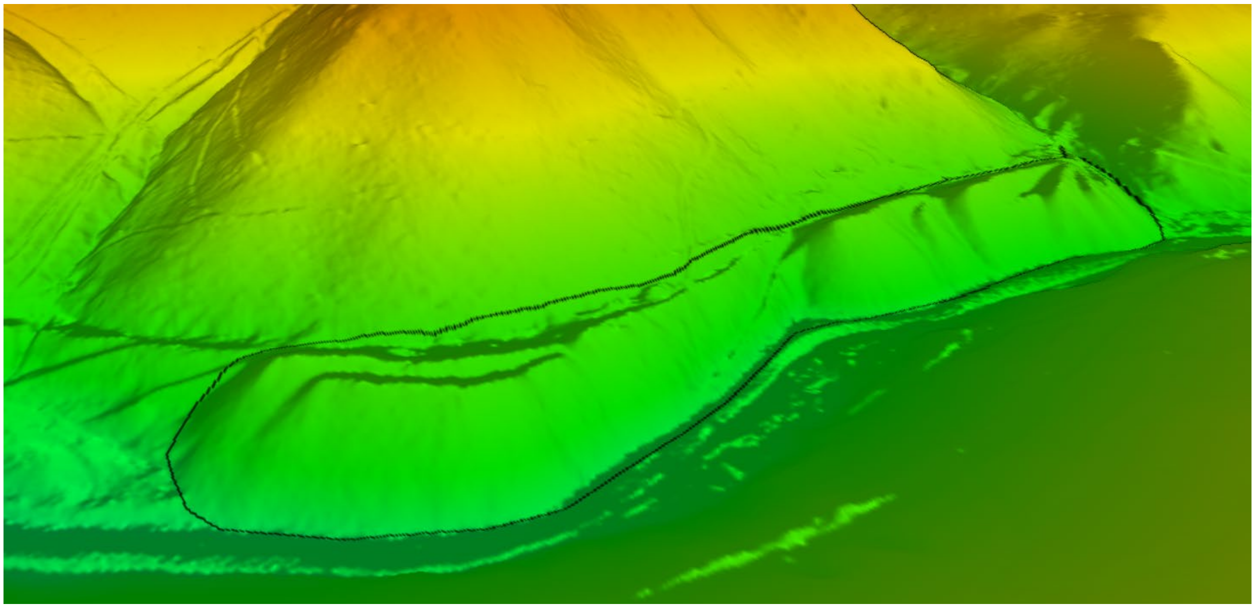
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

EBW_808221249(B)

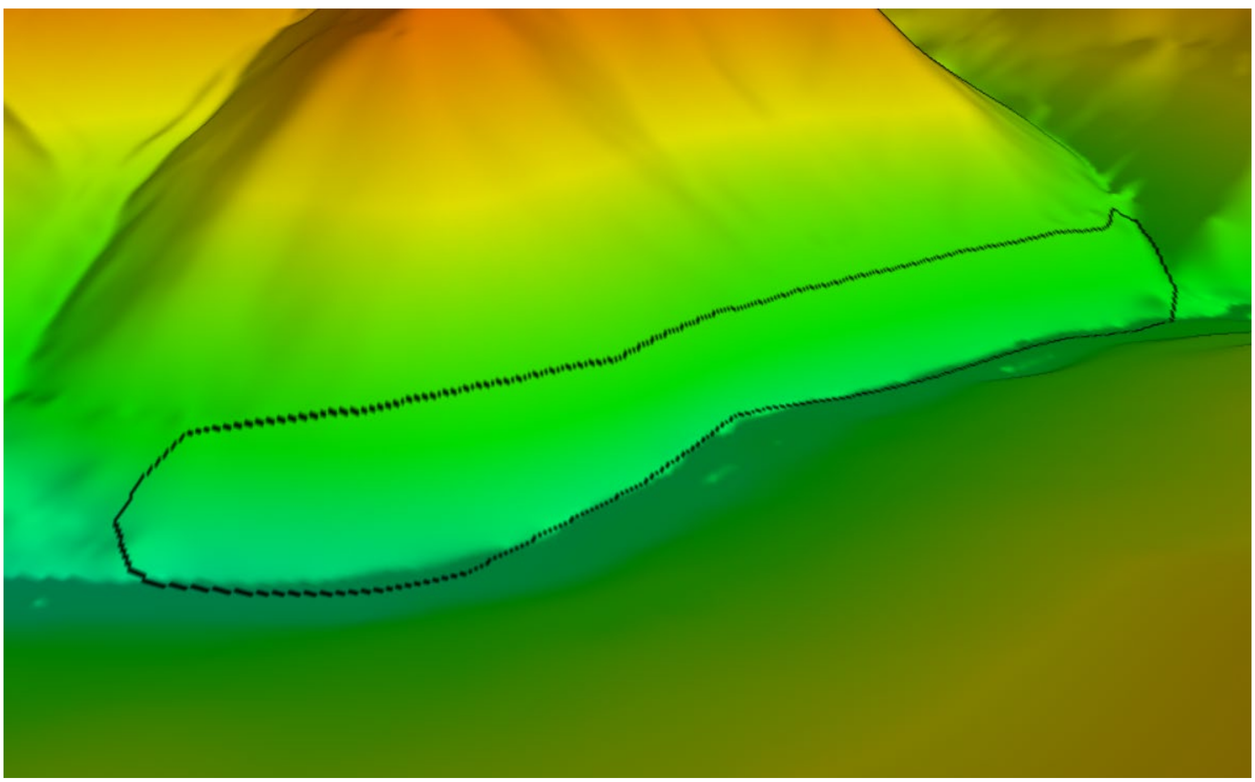
OBJECTID *	Value	Count	AREA	VOLUME
1	1	4077	82559.25	478988.1681
2	2	293	5933.25	-9299.674072
3	3	1	20.25	7.813751
4	4	3	60.75	17.780548
5	5	42	850.5	-833.849121
6	6	1	20.25	-4.721375
7	7	2	40.5	6.431946
8	8	1	20.25	-2.654846
9	9	24	486	-541.95694
10	10	1	20.25	0.617981
11	11	1	20.25	-0.365845
12	12	1	20.25	-4.187439
13	13	2	40.5	-2.741364
14	14	13	263.25	-150.322632
15	15	1	20.25	2.375519
16	16	5	101.25	-56.3302
17	17	1	20.25	-10.83197
18	18	293	5933.25	-10109.61227
19	19	1	20.25	-1.505402
20	20	1	20.25	-3.913055
21	21	1	20.25	11.914673
22	22	1	20.25	1.31012
23	23	1	20.25	-30.085785
24	24	1	20.25	-15.597839
25	25	4	81	22.778778
26	26	1	20.25	1.50293
27	27	16	324	-293.716461
28	28	1	20.25	-11.417816
29	29	3	60.75	-15.948853
30	30	1	20.25	-1.188995
31	31	1	20.25	-2.511475
			CF	**457667.5605**
			CY	**16950.65039**

Unique ID: GEM_62922457

Current Surface:



Historical Surface:



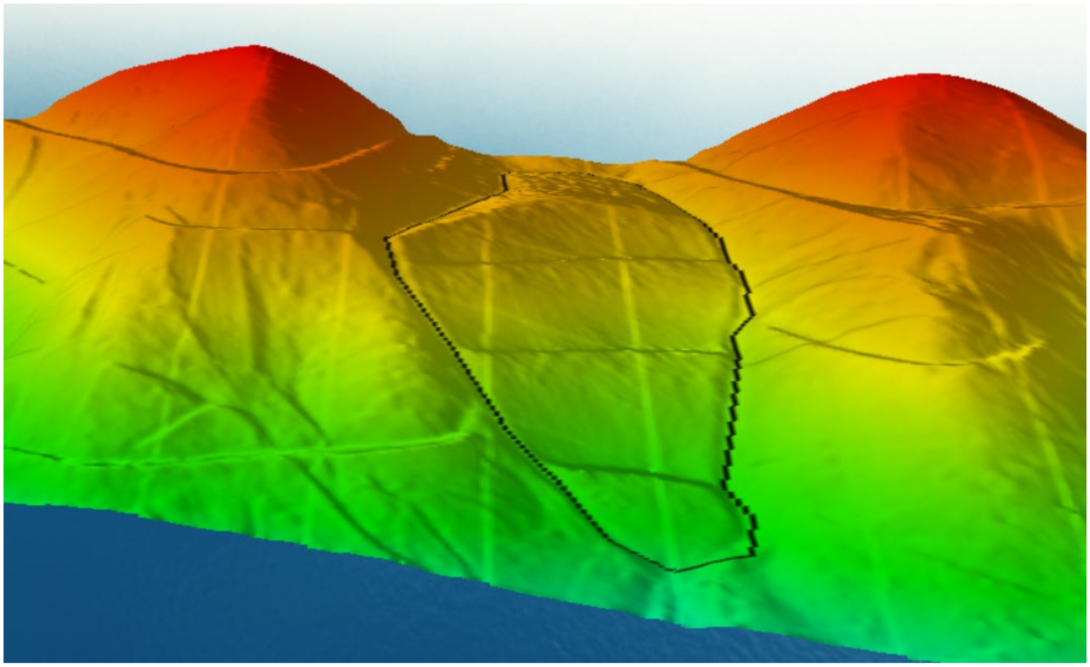
Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	3	147	113.3125
2	2	17	833	-715.356934
3	3	4290	210210	4876642.301
4	4	3	147	-128.768555
5	5	14	686	-1186.216309
6	6	2	98	-23.387451
7	7	42	2058	-1764.933105
8	8	13	637	-232.690186
9	9	2	98	-43.879883
10	10	2	98	23.184082
11	11	4	196	-35.003418
12	12	1	49	-0.705811
13	13	2	98	-13.506104
14	14	388	19012	-68429.64844
15	15	82	4018	-8712.872314
16	16	1	49	11.807373
17	17	1	49	12.046631
18	18	1	49	7.524658
19	19	1	49	10.072754
20	20	1	49	33.795166
21	21	2	98	36.534668
22	22	160	7840	-27165.51148
23	23	1	49	18.040039
24	24	2	98	26.437988
25	25	2	98	123.050293
26	26	1	49	-14.199951
27	27	1	49	-30.684814
28	28	1	49	-22.932861
29	29	1	49	-15.300537
30	30	2	98	-100.536133
				4768421.972 CF

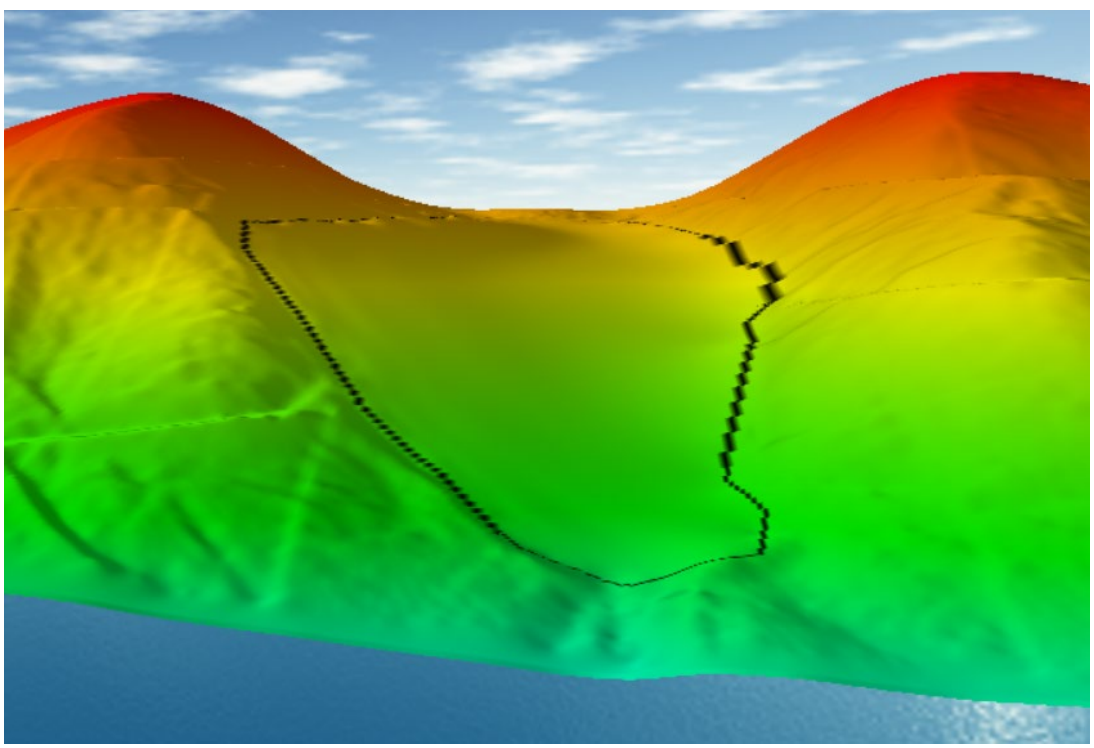
176608 CY

Unique ID: GEM_70622606

Current Surface:



Historical Surface:



Process Documentation:
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4: Create new grid using the trimmed contours.
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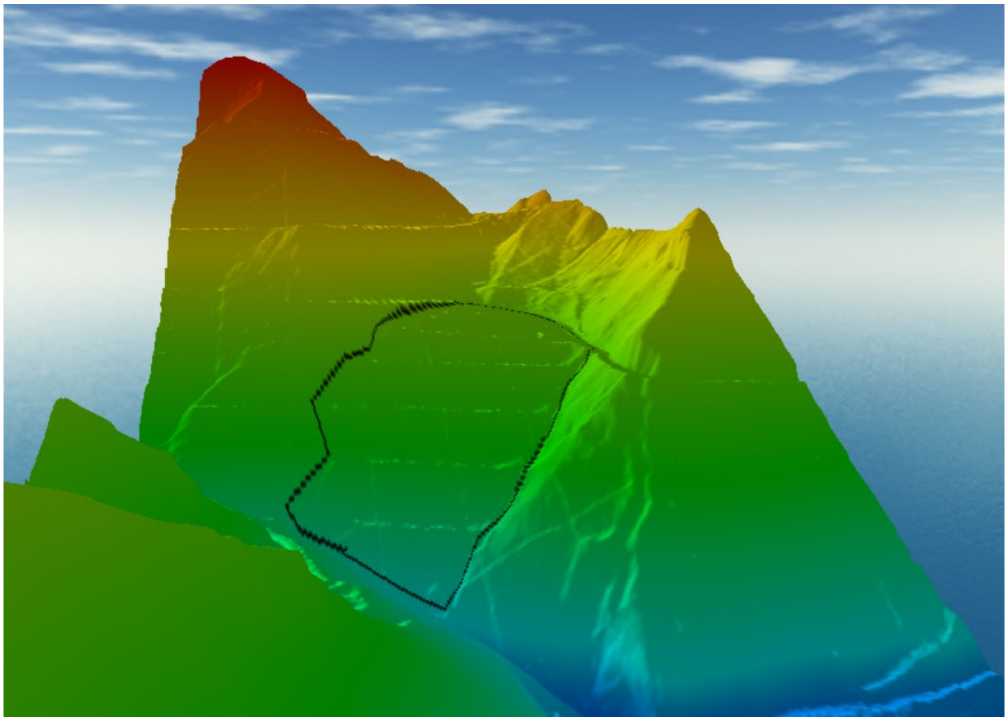
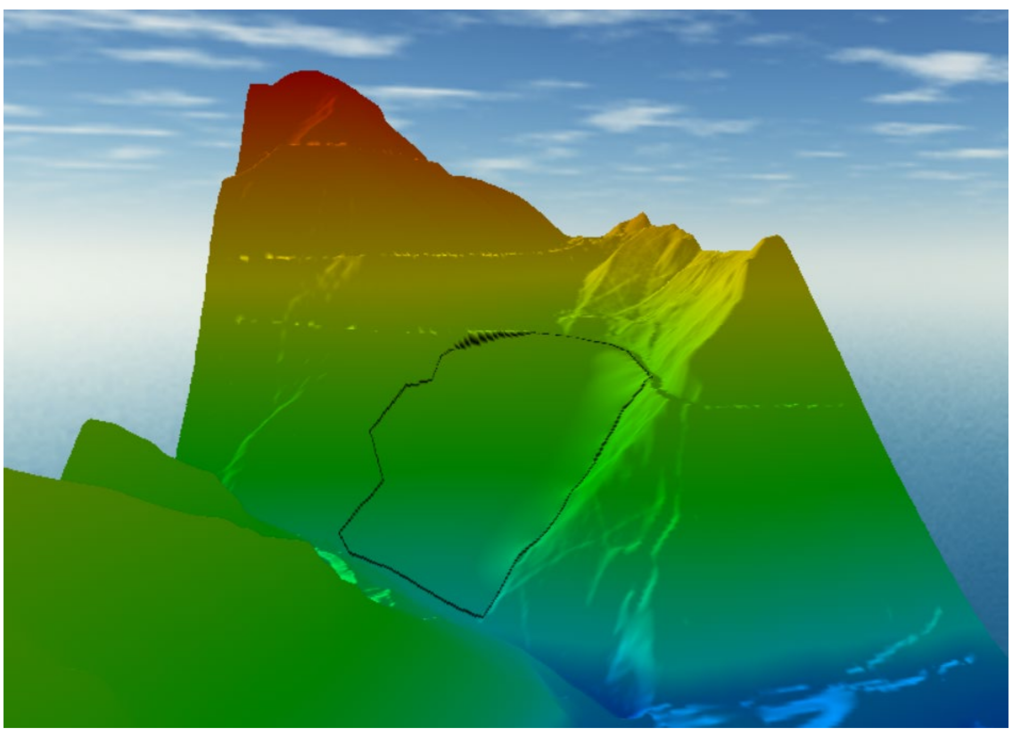
Rowid	VALUE	COUNT	AREA	VOLUME
0	1	11659	125495.9296	1035716.4
1	2	35	376.735358	-241.367112
2	3	1	10.763867	4.027253
3	4	1	10.763867	4.535751
4	5	2	21.527735	10.018858
5	6	1	10.763867	3.781544
6	7	1	10.763867	-0.647777
7	8	213	2292.703748	-3254.650812
8	9	1	10.763867	-0.521638
9	10	1	10.763867	-0.017081
10	11	45	484.374031	-168.297113
11	12	2	21.527735	-1.927563
12	13	3	32.291602	-2.340143
13	14	2	21.527735	-1.994574
14	15	3	32.291602	-14.374598
15	16	1	10.763867	-1.926249
16	17	1	10.763867	-0.067011
17	18	1	10.763867	-0.86195
18	19	1	10.763867	-3.123256
19	20	2	21.527735	-5.500189
20	21	1	10.763867	-0.019709
21	22	1	10.763867	-0.91188
22	23	1	10.763867	-2.265247
23	24	1	10.763867	-1.739668
24	25	2	21.527735	-4.830075
25	26	1	10.763867	-0.420464
26	27	4	43.055469	-8.827107
27	28	2	21.527735	-4.291356
28	29	8	86.110939	-26.738855
29	30	1	10.763867	2.261306
				1031993.363 CF
				38222 CY

Unique ID: GEM_70722505

Current Surface:



Historical Surface:



Process Documentation:
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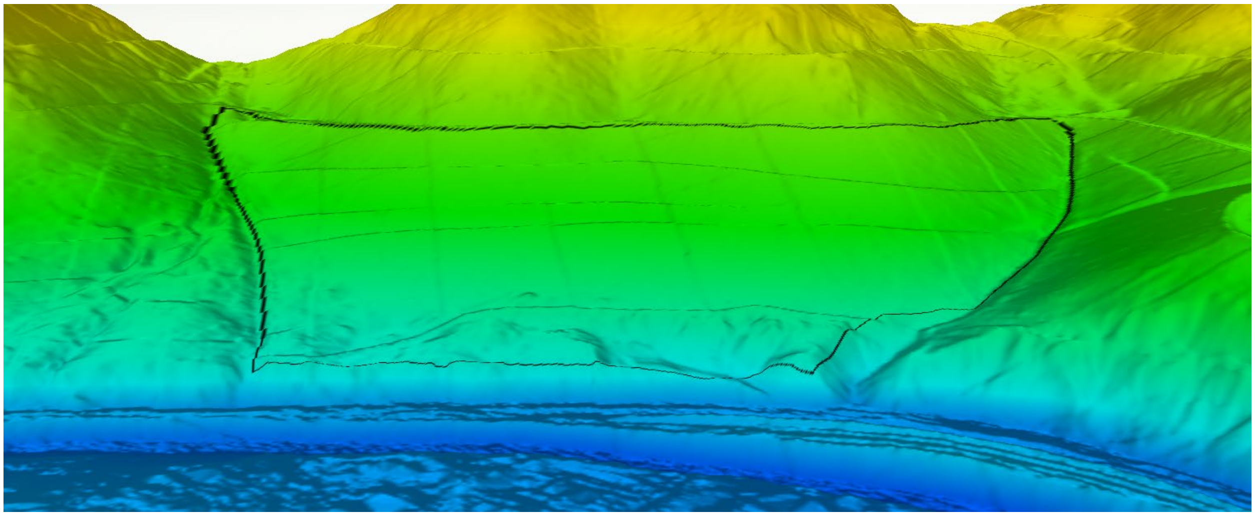
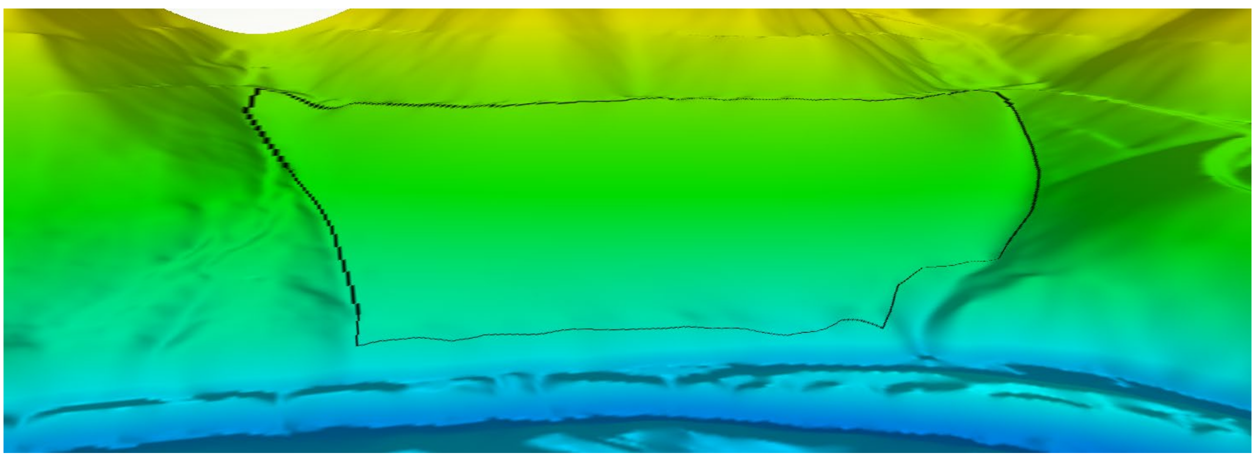
Rowid	VALUE	COUNT	AREA	VOLUME	
0	1	1	10.763867	-0.458568	
1	2	1	10.763867	-3.064128	
2	3	1	10.763867	-6.517185	
3	4	22416	241282.8508	3973199.721	
4	5	244	2626.383636	-2862.632918	
5	6	8	86.110939	31.045979	
6	7	1	10.763867	-1.58068	
7	8	2	21.527735	10.239602	
8	9	15	161.45801	-49.206063	
9	10	2	21.527735	-3.073326	
10	11	3	32.291602	-2.722502	
11	12	20	215.277347	-95.773717	
12	13	42	452.082429	-194.862527	
13	14	1	10.763867	7.866611	
14	15	16	172.221878	-158.891869	
15	16	3	32.291602	-4.908912	
16	17	1	10.763867	-0.580765	
17	18	2	21.527735	-5.451573	
18	19	1	10.763867	-2.324375	
19	20	1	10.763867	-2.564828	
20	21	1	10.763867	-2.425549	
21	22	3	32.291602	-5.046877	
22	23	541	5823.252242	-5455.612037	
23	24	1	10.763867	8.587968	
24	25	1	10.763867	0.001314	
25	26	3	32.291602	9.569488	
26	27	1	10.763867	7.798285	
27	28	7	75.347072	47.949928	
28	29	102	1097.914471	-1634.432554	
29	30	12	129.166408	-94.771174	
30	31	1	10.763867	-1.250879	
31	32	2	21.527735	-1.525494	
32	33	1	10.763867	-2.111515	
33	34	1	10.763867	-1.099775	
34	35	10	107.638674	-21.391084	
35	36	28	301.388286	-529.706574	
36	37	3	32.291602	-1.718645	
37	38	1	10.763867	-2.496502	
38	39	1	10.763867	-1.221972	
39	40	1	10.763867	-0.040732	
40	41	11	118.402541	-22.306906	
41	42	3	32.291602	-0.995973	
42	43	1	10.763867	-0.470394	
43	44	10	107.638674	-11.339377	
44	45	15	161.45801	-49.727701	
				3962088.474	CF
				146744	CY

Unique ID: GEM_71122329

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	3	75	-49.79248
2	2	137	3425	-5785.38513
3	3	19	475	474.279785
4	4	1	25	-16.348267
5	5	11085	277125	2424441.8
6	6	2	50	-32.330322
7	7	1	25	-16.522217
8	8	10	250	-137.731934
9	9	1	25	-19.915771
10	10	2	50	-39.865112
11	11	3815	95375	-232502.979
12	12	1	25	-5.145264
13	13	4	100	-96.725464
14	14	1	25	-18.652344
15	15	3	75	-18.484497
16	16	1	25	-8.364868
17	17	1	25	-0.646973
18	18	1	25	-1.858521
19	19	3	75	-12.606812
20	20	1	25	-0.354004
21	21	1	25	-1.385498
22	22	1	25	-2.075195
23	23	1	25	-1.074219
24	24	1	25	3.146362
25	25	1	25	-2.423096
26	26	1	25	7.74231
27	27	2	50	-6.799316
28	28	3	75	17.06543
29	29	5	125	43.530273
30	30	1	25	-4.296875
31	31	31	775	-583.502197
32	32	1	25	-5.142212
33	33	1	25	-0.772095
34	34	4	100	127.392578
35	35	1	25	3.311157
36	36	1	25	14.108276
37	37	1	25	4.205322
38	38	8	200	-192.697144
39	39	1	25	-13.467407
40	40	1	25	-14.480591
41	41	2	50	29.193115
42	42	1	25	9.368896
43	43	1	25	6.231689
44	44	1	25	6.298828
45	45	11	275	-214.73999
46	46	2	50	-11.227417

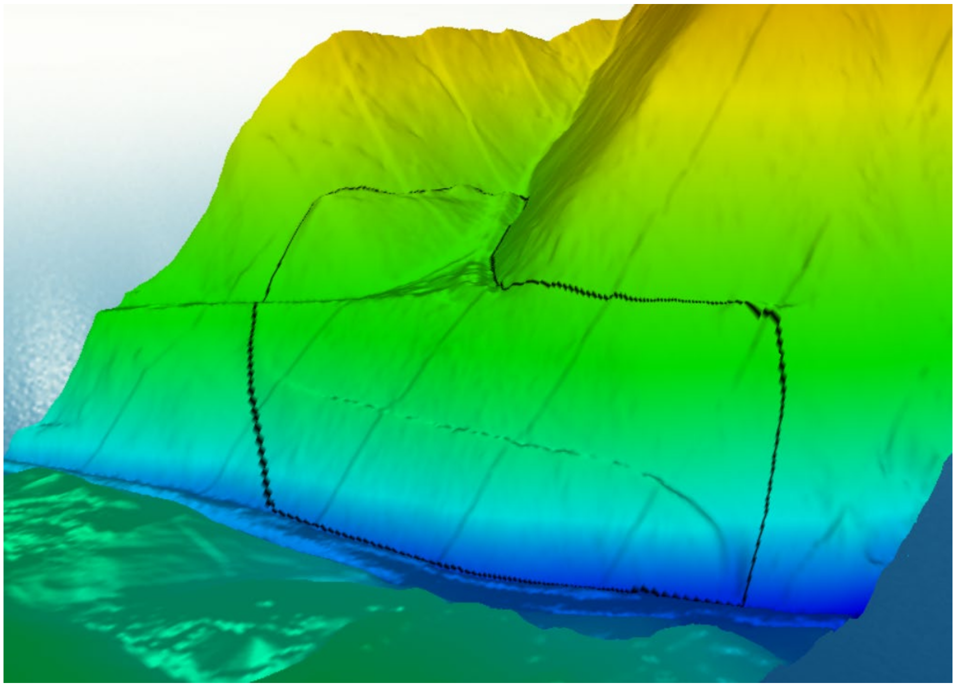
OBJECTID *	Value	Count	AREA	VOLUME
47	47	1	25	-6.213379
48	48	1	25	5.004883
49	49	1	25	1.757813
50	50	1	25	2.862549
51	51	5	125	47.259521
52	52	1	25	9.70459
53	53	1	25	0.418091
54	54	37	925	-941.323853
55	55	1	25	-18.002319
56	56	46	1150	1018.13965
57	57	1	25	18.734741
58	58	1	25	29.63562
59	59	1	25	3.607178
60	60	2	50	27.459717
61	61	2	50	19.827271
62	62	1	25	-1.327515
63	63	1	25	1.611328
64	64	28	700	476.345825
65	65	1	25	24.627686
66	66	1	25	7.983398
67	67	3	75	12.973022
68	68	1	25	7.406616
69	69	1	25	6.842041
70	70	327	8175	-10871.7682
71	71	3	75	-11.61499
72	72	1	25	-2.798462
73	73	1	25	13.4552
74	74	4	100	38.94043
75	75	1	25	13.208008
76	76	1	25	-3.781128
77	77	1	25	-2.999878
78	78	4	100	-19.696045
79	79	1	25	7.052612
80	80	1	25	-1.296997
81	81	1	25	2.270508
82	82	1	25	-2.282715
83	83	4	100	57.662964
84	84	3	75	32.443237
85	85	1	25	2.471924
86	86	13	325	133.670044
87	87	1	25	10.302734
88	88	1	25	16.351318
89	89	7	175	-139.349365
90	90	1	25	-1.2146
91	91	1	25	7.437134
92	92	1	25	4.660034

OBJECTID *	Value	Count	AREA	VOLUME
93	93	1	25	0.222778
94	94	1	25	3.448486
95	95	1	25	1.306152
96	96	3	75	32.272339
97	97	1	25	30.267334
98	98	1	25	10.632324
99	99	1	25	5.813599
100	100	1	25	12.301636
101	101	1	25	4.074097
102	102	1	25	8.483887
103	103	1	25	-8.364868
104	104	1	25	9.631348
105	105	16	400	371.966553
106	106	3	75	30.432129
107	107	1	25	4.644775
108	108	1	25	10.168457
109	109	1	25	-8.285522
110	110	3	75	-60.366821
111	111	1	25	10.647583
112	112	1	25	-12.289429
113	113	1	25	13.461304
114	114	14	350	-292.791748
115	115	1	25	-16.296387
116	116	1	25	-1.748657
117	117	2	50	-23.7854
118	118	1	25	-0.167847
119	119	1	25	8.303833
120	120	1	25	8.984375
121	121	1	25	12.332153
122	122	1	25	-7.876587
123	123	150	3750	-2998.58093
124	124	1	25	-7.739258
125	125	3	75	-29.400635
126	126	1	25	0.628662
127	127	1	25	11.151123
128	128	1	25	1.287842
129	129	3	75	92.288208
130	130	2	50	3.994751
131	131	1	25	1.296997
132	132	1	25	12.460327
133	133	1	25	0.921631
134	134	1	25	28.128052
135	135	3	75	38.735962
136	136	54	1350	-3078.57056
				2169642.36 CF

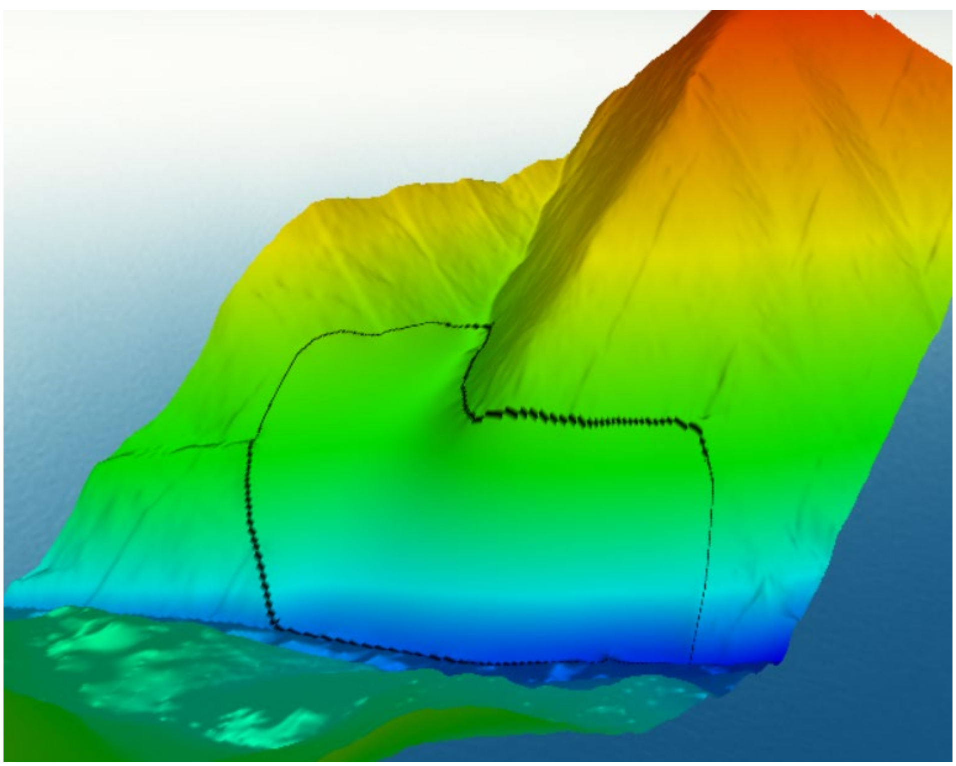
OBJECTID *	Value	Count	AREA	VOLUME
				80357 CY

Unique ID: GEM_71122657

Current Surface:



Historical Surface:



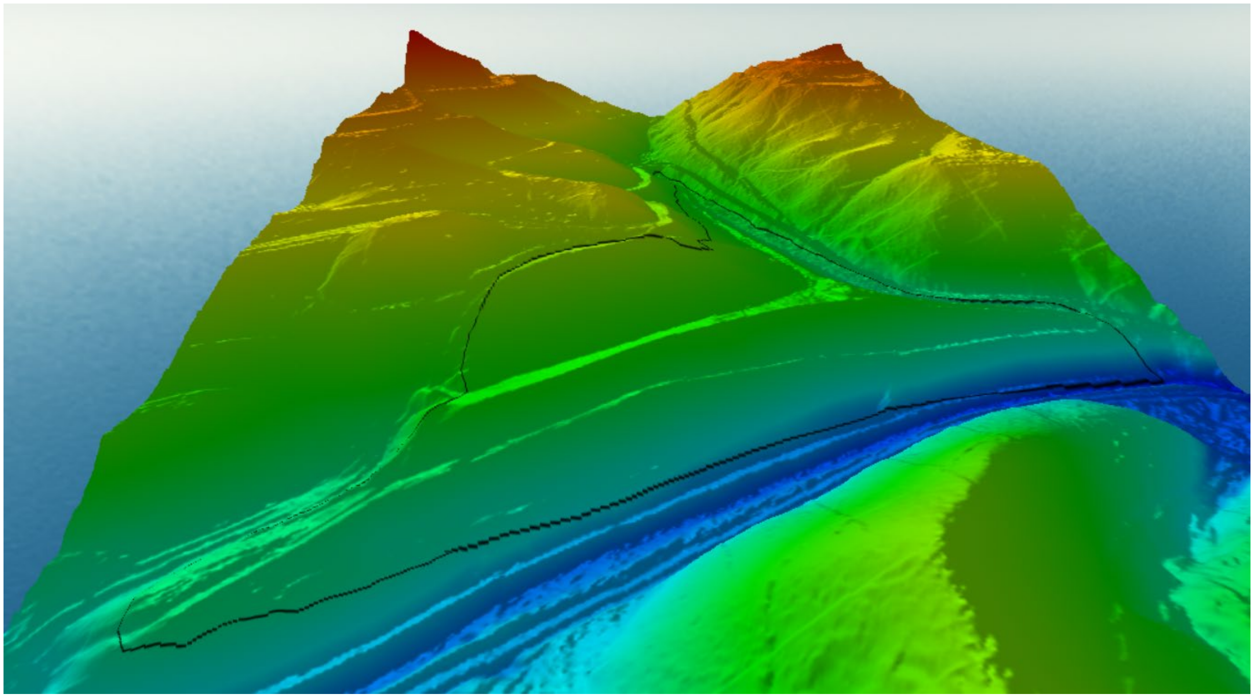
Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

Rowid	VALUE	COUNT	AREA	VOLUME
0	1	500	5381.933681	-9540.324946
1	2	29	312.152153	-149.221207
2	3	10536	113408.1065	1196438.184
3	4	1	10.763867	-0.41915
4	5	2	21.527735	-6.521127
5	6	1	10.763867	-1.479506
6	7	1	10.763867	4.134996
7	8	22	236.805082	-117.765276
8	9	2	21.527735	-8.930909
9	10	1	10.763867	-3.622556
10	11	1	10.763867	-0.76209
11	12	1	10.763867	-1.312635
12	13	2	21.527735	-5.78006
13	14	1	10.763867	-0.826474
14	15	12	129.166408	-87.494527
15	16	1	10.763867	-1.733098
16	17	1	10.763867	-0.897427
17	18	2	21.527735	-6.02971
18	19	5	53.819337	-22.657731
19	20	4	43.055469	-31.299571
20	21	41	441.318562	-464.593848
21	22	4	43.055469	-7.284531
22	23	18	193.749612	-68.592062
23	24	4	43.055469	-8.907258
24	25	3	32.291602	-17.558296
25	26	3	32.291602	-29.134183
26	27	1	10.763867	-5.106004
27	28	1	10.763867	-5.669688
28	29	5	53.819337	-9.519558
29	30	2	21.527735	-2.878861
30	31	1	10.763867	-2.856524
31	32	37	398.263092	-236.848442
32	33	6	64.583204	-21.276771
33	34	2	21.527735	-6.674859
34	35	7	75.347072	-13.20387
35	36	75	807.290052	-645.588961
36	37	11	118.402541	-86.900622
37	38	4	43.055469	-25.909753
38	39	1	10.763867	-5.939048
39	40	9	96.874806	-59.567862
40	41	89	957.984195	-1664.805791
41	42	1	10.763867	-1.085322
42	43	1	10.763867	-1.696308
43	44	8	86.110939	-78.239073
44	45	8	86.110939	-45.168299
45	46	10	107.638674	-117.365835

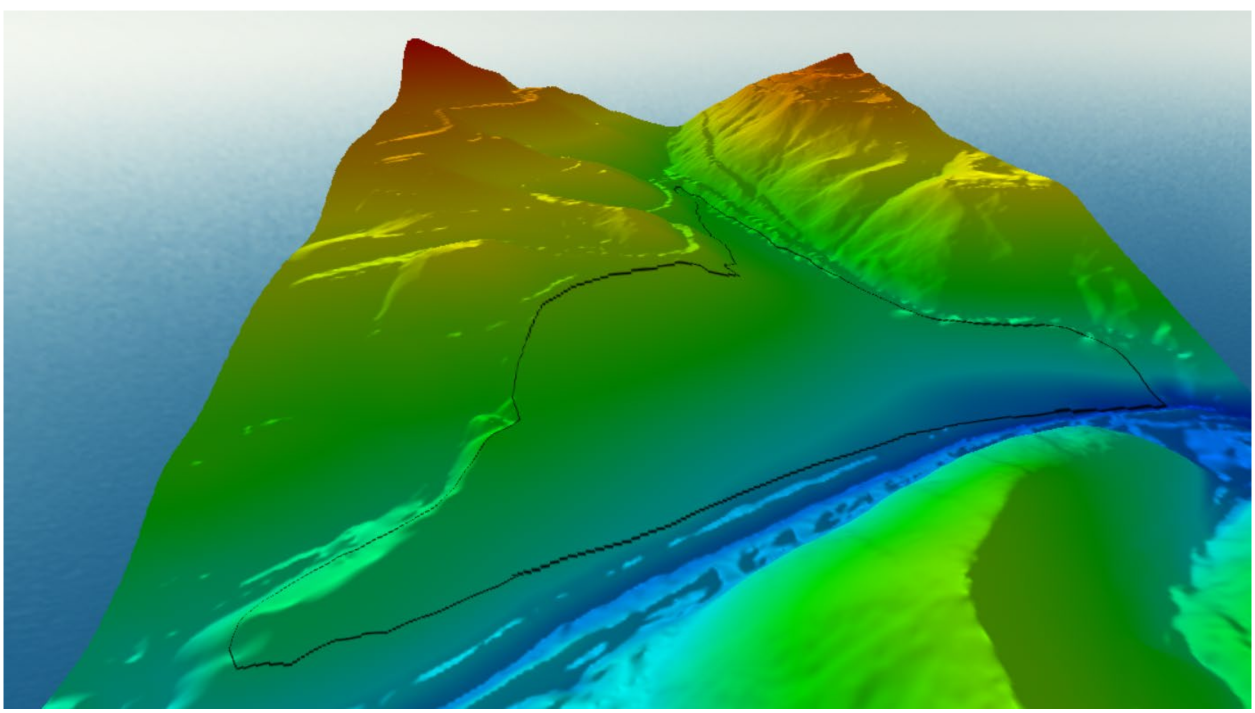
Rowid	VALUE	COUNT	AREA	VOLUME	
46	47	3	32.291602	-16.243033	
47	48	13	139.930276	-120.653335	
48	49	1	10.763867	-8.729875	
49	50	1	10.763867	-4.828761	
50	51	2	21.527735	-5.43712	
51	52	4	43.055469	-29.855541	
				1182637.122	CF
				43801	CY

Unique ID: GEM_71222204

Current Surface:



Historical Surface:



Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

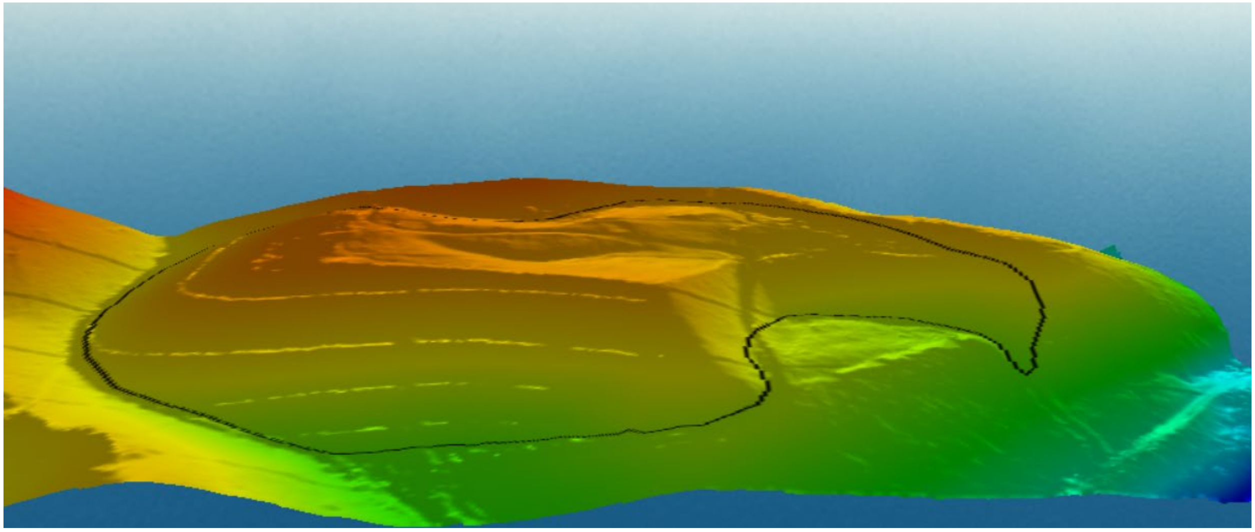
OBJECTID *	Value	Count	AREA	VOLUME
1	1	2826	34618.5	-71663.37778
2	2	52	637	537.322205
3	3	6	73.5	25.603577
4	4	226	2768.5	2308.045349
5	5	1	12.25	4.702911
6	6	1	12.25	1.513306
7	7	1	12.25	-4.789642
8	8	1	12.25	-0.400757
9	9	1	12.25	0.134583
10	10	2	24.5	1.220215
11	11	45	551.25	532.399475
12	12	1	12.25	-2.425476
13	13	1	12.25	-9.60321
14	14	1	12.25	-2.066589
15	15	1	12.25	0.49646
16	16	41780	511805	9858890.976
17	17	2	24.5	-8.52655
18	18	1	12.25	-2.129395
19	19	86	1053.5	-1880.392944
20	20	1	12.25	-4.115234
21	21	2698	33050.5	-51234.47058
22	22	18	220.5	96.63324
23	23	3	36.75	-9.651062
24	24	39	477.75	316.379578
25	25	9	110.25	57.589355
26	26	76	931	590.539124
27	27	18	220.5	117.903259
28	28	7	85.75	17.498718
29	29	2	24.5	-0.520386
30	30	1	12.25	-2.485291
31	31	1	12.25	-0.127106
32	32	2	24.5	-4.411316
33	33	3	36.75	1.375732
34	34	1	12.25	-0.601135
35	35	4	49	-3.621765
36	36	3	36.75	-15.207825
37	37	37	453.25	-188.197205
38	38	1	12.25	2.365662
39	39	6	73.5	-22.873047
40	40	1	12.25	-0.002991
41	41	9713	118984.25	-349788.0761
42	42	1	12.25	2.712585
43	43	13	159.25	33.528992
44	44	2	24.5	6.098083
45	45	10	122.5	67.692017
46	46	1	12.25	5.027405

OBJECTID *	Value	Count	AREA	VOLUME
47	47	1	12.25	1.61499
48	48	2	24.5	-7.666718
49	49	18	220.5	101.549988
50	50	1	12.25	0.104675
51	51	28	343	129.803345
52	52	45	551.25	470.030945
53	53	306	3748.5	3842.459534
54	54	1	12.25	0.765625
55	55	3	36.75	5.954529
56	56	1	12.25	-1.040771
57	57	7	85.75	10.721741
58	58	3	36.75	6.471924
59	59	8	98	21.380676
60	60	2	24.5	1.268066
61	61	17	208.25	42.546021
62	62	1	12.25	-0.161499
63	63	1	12.25	0
64	64	2	24.5	1.330872
65	65	5	61.25	-6.323883
66	66	6	73.5	26.132935
67	67	1	12.25	2.652771
68	68	13	159.25	-7.576996
69	69	4	49	6.310425
70	70	11	134.75	27.185669
71	71	3	36.75	3.244934
72	72	40	490	-80.093048
73	73	2	24.5	9.660034
74	74	1	12.25	3.421387
75	75	64	784	-252.405029
76	76	1	12.25	0.708801
77	77	3	36.75	7.040161
78	78	1	12.25	4.453186
79	79	1	12.25	0.062805
80	80	2	24.5	-12.433929
81	81	15	183.75	-150.183624
82	82	1	12.25	7.796814
83	83	12	147	118.588135
84	84	1	12.25	4.18103
85	85	1	12.25	3.469238
86	86	3	36.75	12.04364
87	87	19	232.75	109.13147
88	88	197	2413.25	-1355.456818
89	89	25	306.25	155.978149
90	90	1	12.25	0.194397
91	91	1	12.25	1.961914
92	92	7	85.75	23.96167

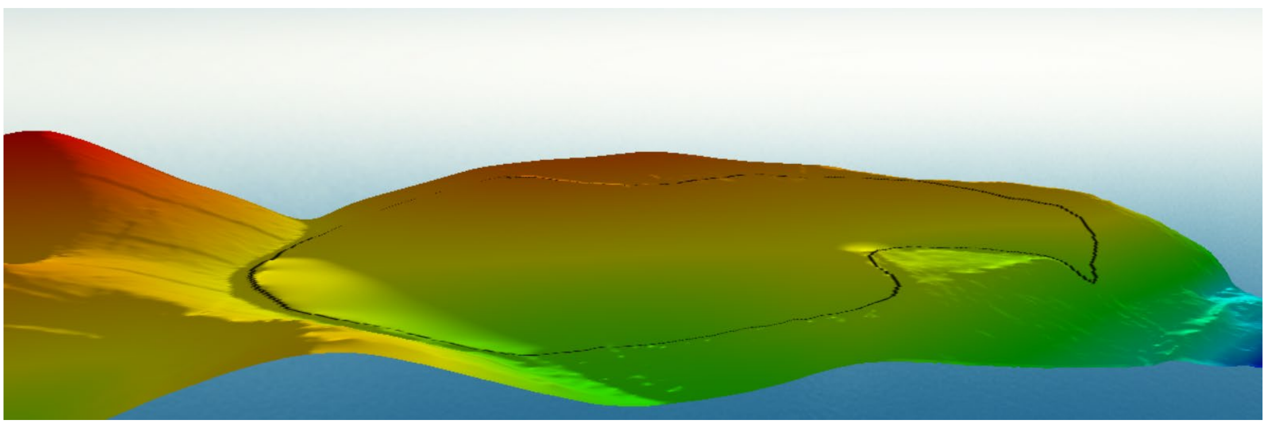
OBJECTID *	Value	Count	AREA	VOLUME	
93	93	4	49	2.839691	
94	94	3	36.75	4.360474	
95	95	452	5537	-9257.877686	
96	96	1	12.25	2.802307	
97	97	1	12.25	0.894226	
98	98	1	12.25	-0.693848	
99	99	3	36.75	14.783142	
100	100	1	12.25	0.613098	
101	101	1	12.25	3.92981	
102	102	1	12.25	1.839294	
103	103	2	24.5	2.863617	
104	104	1	12.25	-0.460571	
105	105	12	147	-112.813049	
106	106	1	12.25	-0.922638	
107	107	1	12.25	-1.568634	
				9382721.114	CF
				347508	CY

Unique ID: GEM_71222525

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

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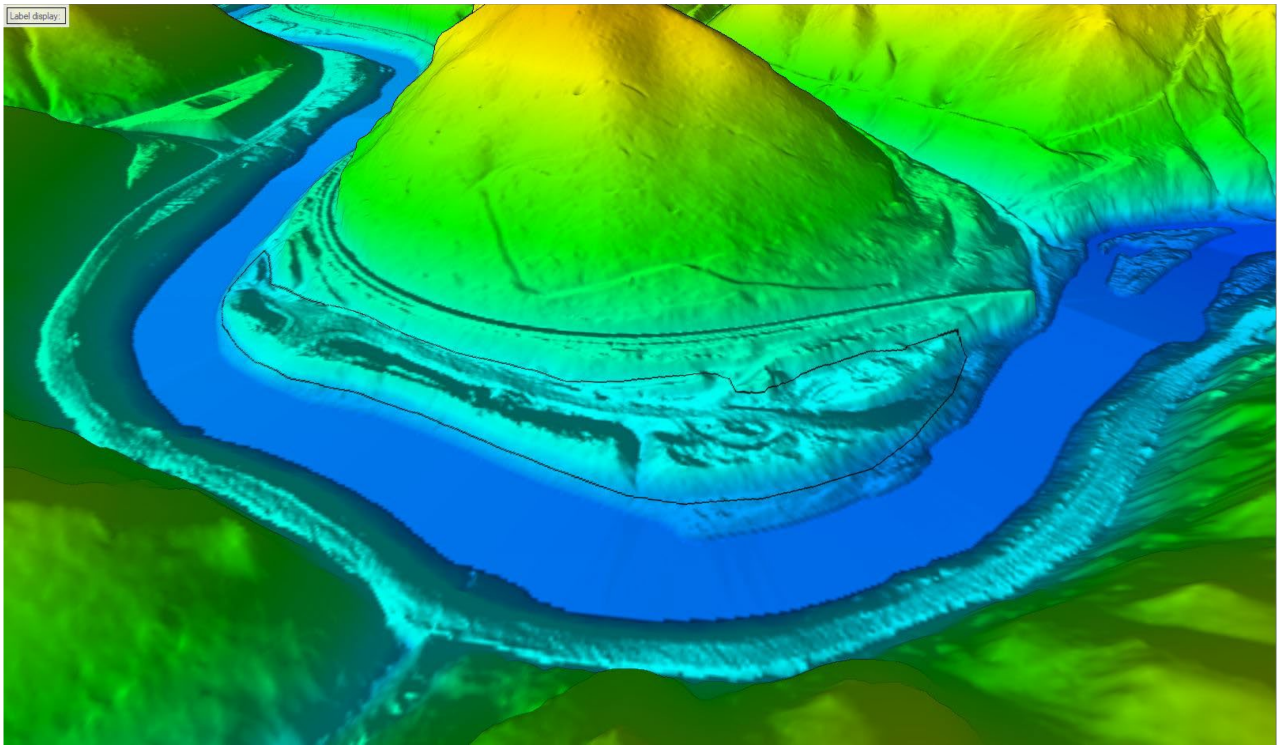
Rowid	VALUE	COUNT	AREA	VOLUME
0	1	1	10.763867	-6.543464
1	2	1	10.763867	-7.58674
2	3	2	21.527735	-5.332004
3	4	1	10.763867	-7.242485
4	5	1	10.763867	-5.439747
5	6	17	182.985745	49.336144
6	7	2	21.527735	-3.713219
7	8	1	10.763867	-3.119314
8	9	28757	309536.5337	6785851.614
9	10	1	10.763867	0.96181
10	11	3276	35262.42948	-78144.6338
11	12	1	10.763867	0.81202
12	13	4	43.055469	8.03611
13	14	1	10.763867	-2.241596
14	15	2	21.527735	-4.769634
15	16	2	21.527735	4.052218
16	17	2	21.527735	1.077438
17	18	1	10.763867	0
18	19	2	21.527735	-13.076417
19	20	1	10.763867	1.807993
20	21	2	21.527735	6.433093
21	22	1	10.763867	3.119314
22	23	1	10.763867	-3.345313
23	24	3	32.291602	-14.387738
24	25	1	10.763867	1.156275
25	26	1	10.763867	-5.066586
26	27	9	96.874806	-21.230782
27	28	2	21.527735	-0.649091
28	29	3	32.291602	11.221121
29	30	3	32.291602	-9.636499
30	31	3	32.291602	-3.232314
31	32	1	10.763867	-2.846013
32	33	2	21.527735	7.055904
33	34	6	64.583204	-17.112867
34	35	2	21.527735	-1.603017
35	36	1	10.763867	0.065697
36	37	1	10.763867	-0.260162
37	38	2	21.527735	-4.785401
38	39	4	43.055469	-8.049249
39	40	2	21.527735	-2.601618
40	41	3	32.291602	8.490736
41	42	6	64.583204	12.020002
42	43	8	86.110939	20.841854
43	44	15	161.45801	64.480716
44	45	1	10.763867	1.253507
45	46	2	21.527735	1.758063

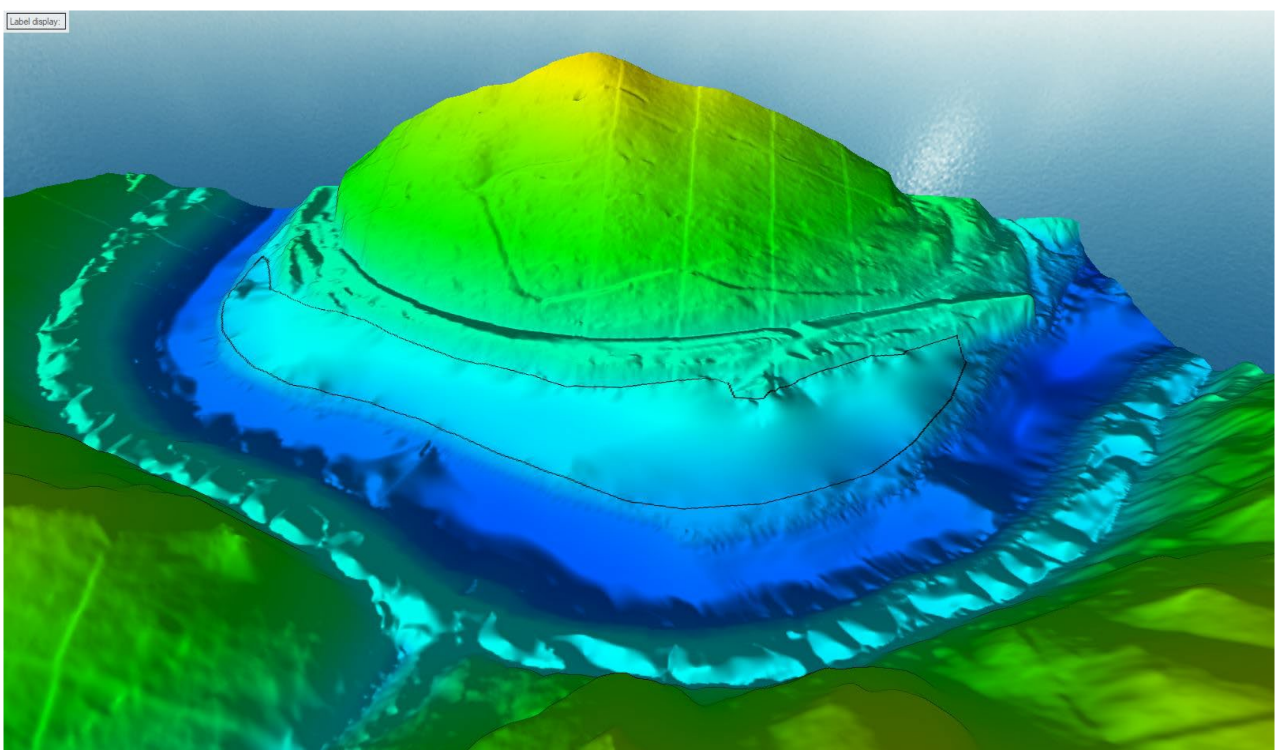
Rowid	VALUE	COUNT	AREA	VOLUME
46	47	7	75.347072	32.559648
47	48	1	10.763867	4.517355
48	49	18	193.749613	-65.484573
49	50	2	21.527735	1.584622
50	51	453	4876.031915	3494.837998
51	52	2	21.527735	6.196582
52	53	1	10.763867	2.154876
53	54	1	10.763867	-0.307464
54	55	8	86.110939	-23.69575
55	56	2	21.527735	-0.964438
56	57	2	21.527735	-5.744584
57	58	9	96.874806	13.449578
58	59	2	21.527735	0.425719
59	60	1	10.763867	-0.998601
60	61	3	32.291602	4.3991
61	62	1	10.763867	1.918365
62	63	3	32.291602	-9.326408
63	64	1	10.763867	-0.438859
64	65	2	21.527735	-6.094094
65	66	1	10.763867	-1.135252
66	67	16	172.221878	-47.825103
67	68	1	10.763867	-0.501928
68	69	2	21.527735	-3.481964
69	70	4	43.055469	-10.243544
70	71	1	10.763867	-0.233883
71	72	1	10.763867	-6.170303
72	73	1	10.763867	-1.156275
73	74	1	10.763867	-0.409952
74	75	3	32.291602	-10.490566
75	76	1	10.763867	-1.497901
76	77	1	10.763867	-0.231255
77	78	3	32.291602	-5.360911
78	79	11	118.402541	-64.719855
				6711052.619 CF
				248557 CY

Unique ID: GEM_71422814

Current Surface:



Historical Surface:



Process Documentation:

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3: Trim contours inside the gob pile boundary.

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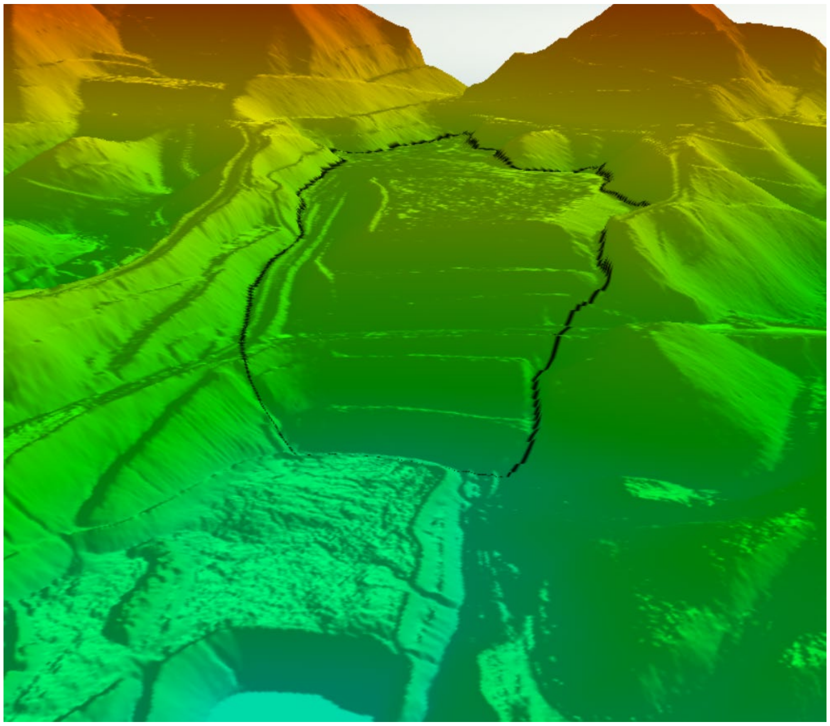
OBJECTID *	Value	Count	AREA	VOLUME
1	1	11732	126281.6919	715946.4349
2	2	1	10.763867	-1.094519
3	3	3	32.291602	-2.915652
4	4	1	10.763867	-1.307379
5	5	974	10484.00681	-12821.98397
6	6	4	43.055469	-18.062852
7	7	28	301.388286	113.295223
8	8	472	5080.545394	-12254.41203
9	9	8	86.110939	84.188632
10	10	27	290.624419	-125.899932
11	11	9	96.874806	-27.893816
12	12	2	21.527735	-3.378162
13	13	7	75.347072	-17.739621
14	14	11	118.402541	-39.432913
15	15	1	10.763867	3.870893
16	16	12	129.166408	-26.86368
17	17	5	53.819337	64.18902
18	18	23	247.568949	-113.802407
19	19	1	10.763867	1.991946
20	20	3	32.291602	6.664348
21	21	8	86.110939	75.144723
22	22	5	53.819337	-11.671806
23	23	8	86.110939	68.630166
24	24	1	10.763867	2.851269
25	25	2	21.527735	11.896491
26	26	18	193.749613	137.616412
27	27	1	10.763867	-0.989403
28	28	3	32.291602	-24.1149
29	29	5	53.819337	46.145877
30	30	1	10.763867	-3.910311
31	31	1	10.763867	-3.397871
32	32	6	64.583204	-13.71631
33	33	1	10.763867	-2.068155
34	34	13	139.930276	-96.838016
35	35	1	10.763867	-3.866951
36	36	1	10.763867	-0.600475
37	37	1	10.763867	-7.185985
38	38	2	21.527735	-8.011145
39	39	1	10.763867	-0.183953
40	40	6	64.583204	-25.804638
41	41	81	871.873256	-752.435324
42	42	1	10.763867	-0.231255
43	43	7	75.347072	-11.449749
44	44	3	32.291602	-10.419613
45	45	9	96.874806	-30.236586
46	46	3	32.291602	-7.024369

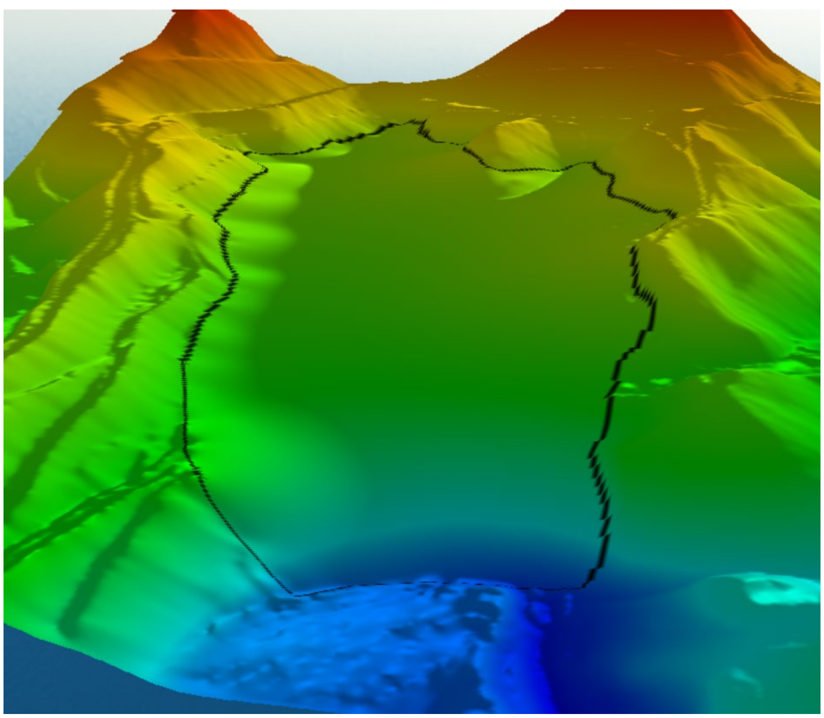
OBJECTID *	Value	Count	AREA	VOLUME	
47	47	3	32.291602	-13.536299	
48	48	1	10.763867	-1.550459	
49	49	54	581.248838	-391.714372	
50	50	1	10.763867	-0.19972	
51	51	2	21.527735	-1.352053	
				689685.6232	CF
				25543.91197	CY

Unique ID: GEM_72122256

Current Surface:



Historical Surface:



Process Documentation:
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3: Trim contours inside the gob pile boundary.
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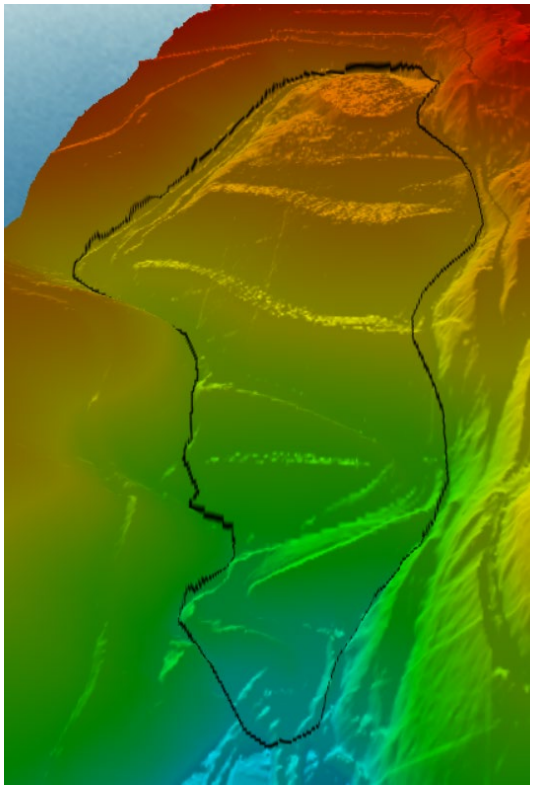
Rowid	VALUE	COUNT	AREA	VOLUME
0	1	2576	92736	-363582.5273
1	2	1	36	20.504883
2	3	3	108	37.661133
3	4	1	36	13.5
4	5	9	324	430.004883
5	6	11	396	646.119141
6	7	3	108	24.802734
7	8	7	252	553.992188
8	9	5	180	151.101563
9	10	36604	1317744	28253081.37
10	11	2	72	8.279297
11	12	98	3528	-4566.858398
12	13	1	36	13.702148
13	14	9	324	238.517578
14	15	3	108	83.373047
15	16	28	1008	2234.197266
16	17	1	36	8.463867
17	18	5	180	99.905273
18	19	2	72	-56.293945
19	20	3	108	25.708008
20	21	1	36	-16.022461
21	22	1	36	-9.246094
22	23	3	108	32.739258
23	24	1	36	16.664063
24	25	2	72	-28.212891
25	26	3	108	-49.350586
26	27	2	72	-11.293945
27	28	7	252	-95.185547
28	29	13	468	468.307617
29	30	1	36	4.297852
30	31	1	36	-21.023438
31	32	1	36	13.957031
32	33	19	684	-586.195313
33	34	2	72	7.655273
34	35	1	36	-14.510742
35	36	1	36	21.770508
36	37	16	576	-420.960938
37	38	1	36	-4.579102
38	39	1	36	-8.516602
39	40	9	324	-125.033203
40	41	2	72	-86.976563
41	42	134	4824	-10962.21094
42	43	1	36	-2.803711
43	44	5	180	-106.549805
44	45	3	108	-32.124023
45	46	4	144	-46.740234

Rowid	VALUE	COUNT	AREA	VOLUME
46	47	3	108	-50.915039
47	48	853	30708	-125839.8721
48	49	183	6588	-33221.38184
49	50	30	1080	-838.450195
50	51	1	36	-34.154297
51	52	1	36	-9.870117
52	53	1	36	-19.415039
53	54	1	36	-32.326172
54	55	2	72	27.931641
55	56	1	36	-3.726563
56	57	2	72	-23.967773
57	58	1	36	-8.182617
58	59	1	36	-2.830078
59	60	93	3348	-6012.325195
60	61	1	36	0.606445
61	62	1	36	10.388672
62	63	24	864	-396.079102
63	64	24	864	-1071.325195
64	65	2	72	-17.894531
65	66	1	36	-28.977539
66	67	1	36	-46.151367
67	68	55	1980	-6346.160156
68	69	15	540	-363.955078
69	70	44	1584	-2252.988281
70	71	1	36	-5.317383
71	72	9	324	-114.547852
72	73	1	36	-18.202148
73	74	1	36	-1.643555
74	75	1	36	43.03125
75	76	135	4860	-6956.542969
76	77	1	36	-52.69043
77	78	2	72	33.389648
78	79	83	2988	-6132.199219
79	80	2	72	-41.774414
80	81	1	36	-12.691406
81	82	5	180	214.584961
				27687776.76 CF

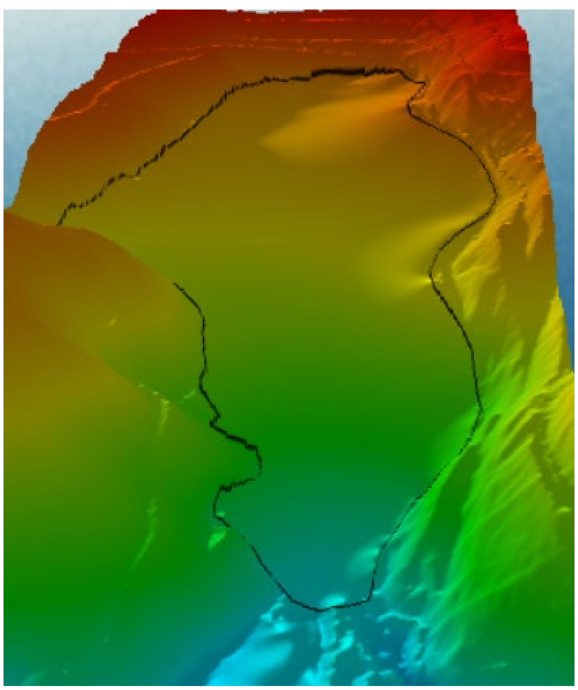
1025473 CY

Unique ID: GEM_72122349

Current Surface:



Historical Surface:



Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

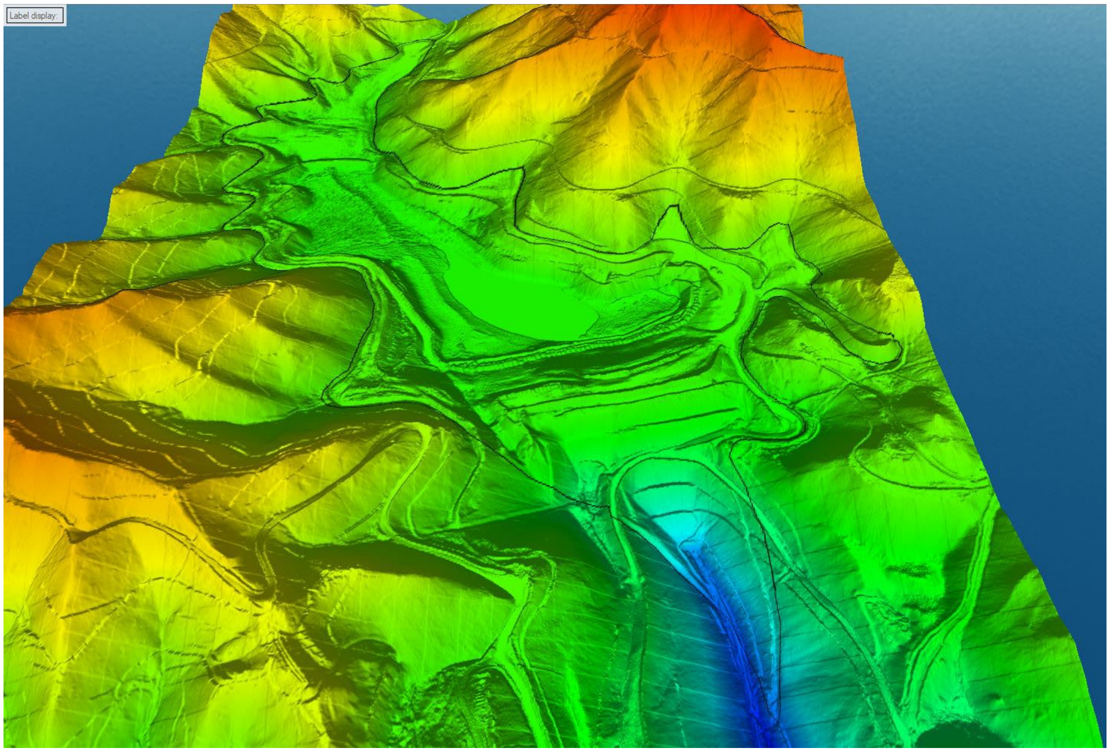
Rowid	VALUE	COUNT	AREA	VOLUME
0	1	24	258.332817	-198.048852
1	2	89939	968091.4666	26213619.7
2	3	2	21.527735	-9.179245
3	4	712	7663.873561	-27468.32784
4	5	63	678.123644	-685.0902
5	6	1	10.763867	4.002288
6	7	1	10.763867	4.567286
7	8	1	10.763867	11.552237
8	9	3324	35779.09511	-98928.6026
9	10	2	21.527735	4.885261
10	11	1	10.763867	5.284701
11	12	1	10.763867	2.215317
12	13	1	10.763867	1.072182
13	14	2	21.527735	5.833932
14	15	1	10.763867	2.168015
15	16	1	10.763867	2.336201
16	17	1	10.763867	1.332344
17	18	1	10.763867	3.63701
18	19	10	107.638674	39.494669
19	20	6	64.583204	20.873388
20	21	19	204.51348	63.387511
21	22	1	10.763867	2.77506
22	23	5	53.819337	11.165936
23	24	4	43.055469	25.035978
24	25	1	10.763867	1.103717
25	26	1	10.763867	0.688509
26	27	1	10.763867	0.754207
27	28	1	10.763867	1.705505
28	29	1	10.763867	2.656804
29	30	520	5597.211028	-10625.16694
30	31	2	21.527735	16.282452
31	32	4	43.055469	5.844444
32	33	1	10.763867	5.401643
33	34	2	21.527735	1.861865
34	35	2	21.527735	7.970413
35	36	1	10.763867	1.555715
36	37	1	10.763867	-0.341627
37	38	1	10.763867	1.705505
38	39	5	53.819337	15.507222
39	40	1	10.763867	-15.051282
40	41	1	10.763867	-2.496502
41	42	1	10.763867	-1.103717
42	43	2	21.527735	-16.124778
43	44	21	226.041215	-203.035288
44	45	2	21.527735	2.204806
45	46	3	32.291602	-3.069384

Rowid	VALUE	COUNT	AREA	VOLUME
46	47	4	43.055469	-35.204626
47	48	6	64.583204	10.795402
48	49	25	269.096684	-272.306661
49	50	4	43.055469	-13.901577
50	51	1	10.763867	-1.48082
51	52	1	10.763867	-4.387275
52	53	2	21.527735	4.03645
53	54	6	64.583204	-42.487844
54	55	1	10.763867	-3.132454
55	56	1	10.763867	-4.36231
56	57	1	10.763867	-2.277073
57	58	1	10.763867	4.131055
58	59	1	10.763867	1.453227
59	60	1	10.763867	-1.763319
60	61	107	1151.733808	-3059.421694
61	62	223	2400.342422	-4053.649848
62	63	1	10.763867	4.502902
63	64	1	10.763867	10.445892
64	65	5	53.819337	13.277451
65	66	1	10.763867	1.616157
66	67	3	32.291602	20.953539
67	68	10	107.638674	-50.681627
68	69	72	774.99845	1145.676504
69	70	97	1044.095134	-1326.603292
70	71	6	64.583204	-31.907929
71	72	1	10.763867	1.377018
72	73	3	32.291602	-3.250709
73	74	5	53.819337	-15.084131
74	75	2	21.527735	-0.315348
75	76	1	10.763867	-0.444115
76	77	1	10.763867	-0.578137
77	78	1448	15586.07994	-59448.48204
78	79	2	21.527735	-8.078156
79	80	5	53.819337	-5.702537
80	81	16	172.221878	-74.975224
81	82	13	139.930276	-47.44143
82	83	7	75.347072	-14.721481
83	84	19	204.51348	-167.004188
84	85	3	32.291602	-3.928706
85	86	2	21.527735	-0.796253
86	87	5	53.819337	-11.093668
87	88	6	64.583204	-5.572456
88	89	13	139.930276	-34.359757
89	90	3	32.291602	-16.313986
90	91	6	64.583204	-4.096892
91	92	3	32.291602	-7.058532

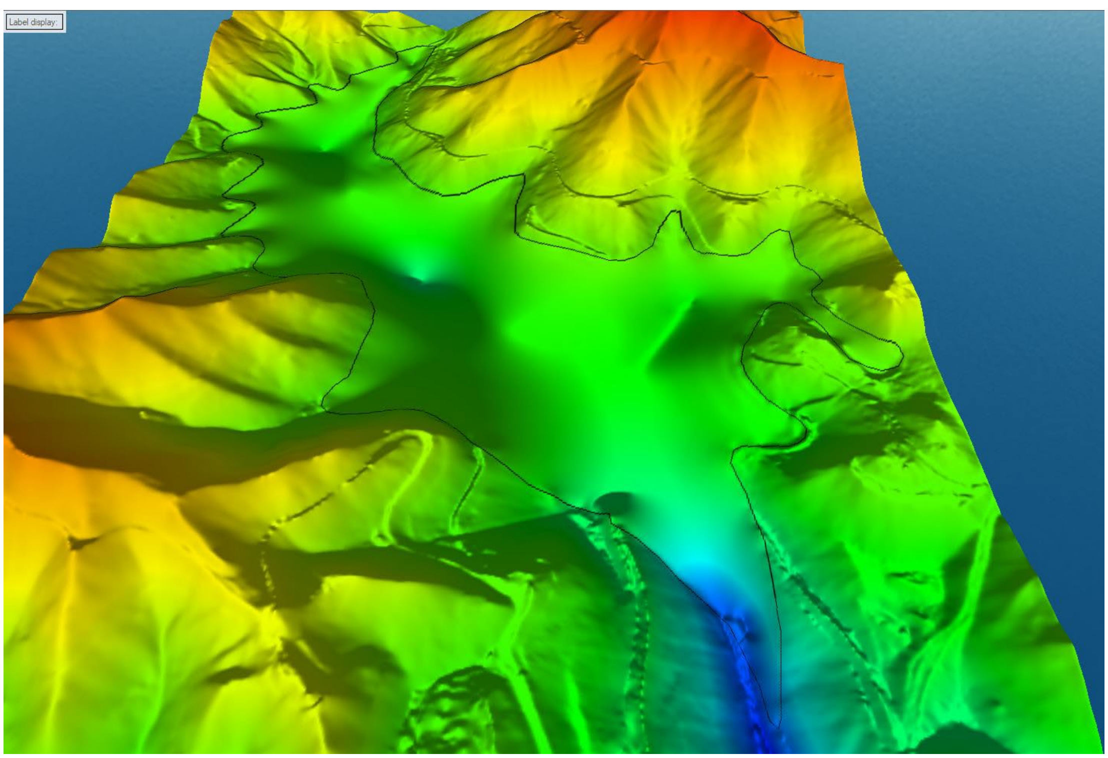
Rowid	VALUE	COUNT	AREA	VOLUME
92	93	5	53.819337	-6.596022
93	94	2	21.527735	-8.878351
94	95	2	21.527735	-2.076039
95	96	2	21.527735	-0.638579
96	97	12	129.166408	-180.769114
97	98	1	10.763867	-0.388929
98	99	1	10.763867	-0.685881
99	100	1	10.763867	-1.788284
100	101	2	21.527735	-1.758063
101	102	9	96.874806	-60.612451
102	103	1	10.763867	4.258508
103	104	2	21.527735	-6.925823
104	105	76	818.053919	1422.493951
105	106	2	21.527735	13.842449
106	107	122	1313.191818	-1067.706791
107	108	14	150.694143	-60.91466
108	109	1	10.763867	-0.92502
109	110	2	21.527735	5.276818
110	111	1	10.763867	0.738439
111	112	6	64.583204	-32.786961
112	113	2	21.527735	-3.568685
113	114	1	10.763867	1.185182
114	115	1	10.763867	-0.473022
115	116	1	10.763867	-0.346882
				26008196.28 CF
				963266 CY

Unique ID: GEM_72122532

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	85369	5463616	147339125.5
2	2	9	576	-391.25
3	3	27	1728	-3112.390625
4	4	4	256	-114.640625
5	5	1	64	-1.890625
6	6	5	320	-122
7	7	25	1600	-2290.84375
8	8	1	64	2.5
9	9	8	512	-250.125
10	10	1	64	-12.234375
11	11	2	128	-94.46875
12	12	3	192	-282.171875
13	13	1	64	-2.734375
14	14	1	64	-8.109375
15	15	1	64	-36.25
16	16	1	64	-49.734375
17	17	40	2560	-2320.859375
18	18	2	128	-78.5
19	19	3709	237376	-1707787.344
20	20	1	64	-30.40625
21	21	2	128	-78.953125
22	22	1	64	22.15625
23	23	2	128	-64.25
24	24	1	64	-1.125
25	25	1	64	12.21875
26	26	1	64	-24.921875
27	27	1	64	36.140625
28	28	1	64	1.515625
29	29	3	192	-15.859375
30	30	3	192	-137.375
31	31	1	64	80.703125
32	32	29	1856	-2449.296875
33	33	49	3136	-3290.46875
34	34	1	64	0.4375
35	35	6	384	-724.9375
36	36	2	128	26.125
37	37	1	64	-6.609375
38	38	1	64	-10.171875
39	39	1	64	-44.203125
40	40	1	64	6.234375
41	41	1	64	-15.78125
42	42	1	64	13.90625
43	43	1	64	-3.203125
44	44	1	64	-29.90625
45	45	3	192	-49.21875
46	46	1	64	7.46875

OBJECTID *	Value	Count	AREA	VOLUME
47	47	2	128	-33.1875
48	48	1	64	-3.3125
49	49	20	1280	-2268.671875
50	50	3	192	-192.78125
51	51	30	1920	-3443.8125
52	52	613	39232	-314484.4688
53	53	15	960	-604.109375
54	54	1	64	-3.484375
55	55	1	64	-22.09375
56	56	10	640	-577.328125
57	57	1	64	-18.453125
58	58	1	64	-14.28125
59	59	39	2496	-3821.28125
60	60	1	64	-2.84375
61	61	1	64	-4.65625
62	62	1	64	-61.109375
63	63	1	64	-6.8125
64	64	6	384	-275.5
65	65	1	64	-13.671875
66	66	1	64	-24.65625
67	67	23	1472	-1679.96875
68	68	1	64	-43.390625
69	69	18	1152	-1162.953125
70	70	1	64	33.453125
71	71	2	128	-48.03125
72	72	11840	757760	-12094350.84
73	73	18	1152	-1433.046875
74	74	332	21248	-58574.95313
75	75	4	256	-107.09375
76	76	22	1408	-1019.921875
77	77	4	256	-117.140625
78	78	1	64	69
79	79	427	27328	-61670.70313
80	80	1	64	-9.109375
81	81	24	1536	-1145.875
82	82	1	64	-54.390625
83	83	1	64	86.375
84	84	4	256	-112.140625
85	85	3	192	-68.203125
86	86	1	64	-14.78125
87	87	2	128	-101.921875
88	88	1	64	-22.65625
89	89	1	64	-7.28125
90	90	18	1152	-1753.46875
91	91	1	64	0
92	92	12	768	-757.265625

OBJECTID *	Value	Count	AREA	VOLUME
93	93	341	21824	-105196.2344
94	94	2	128	64.9375
95	95	29	1856	3303.5625
96	96	1	64	25.046875
97	97	1	64	-39.203125
98	98	1	64	24.25
99	99	1	64	-20.09375
100	100	1	64	-8.859375
101	101	1	64	-35.734375
102	102	1	64	-55.515625
103	103	1	64	4.3125
104	104	1	64	-70.390625
105	105	6	384	-488.484375
106	106	8	512	497.34375
107	107	120	7680	-9716.265625
108	108	2	128	31.953125
109	109	6	384	-437.59375
110	110	74	4736	-6066.609375
111	111	1	64	9.703125
112	112	1	64	-32.796875
113	113	2	128	-86.4375
114	114	1	64	-24.015625
115	115	1	64	-43.859375
116	116	1	64	-12.703125
117	117	9	576	-439.1875
118	118	2	128	-61.53125
119	119	1	64	0.8125
120	120	504	32256	-96655.21875
121	121	1	64	-54.125
122	122	189	12096	-40287.79688
123	123	1	64	-29.34375
124	124	3	192	-150.078125
125	125	2	128	32.0625
126	126	4	256	-244.265625
127	127	2	128	-67.71875
128	128	9	576	-702.90625
129	129	1	64	-25.6875
130	130	29	1856	-1679.5625
131	131	14	896	-856.53125
132	132	1	64	55.5
133	133	8	512	-233.03125
134	134	1	64	-24.484375
135	135	1	64	-2.9375
136	136	4	256	-114.96875
137	137	2	128	-72.890625
138	138	4	256	-69.546875

OBJECTID *	Value	Count	AREA	VOLUME
139	139	1	64	-51.546875
140	140	1	64	-2.6875
141	141	220	14080	-25624.60938
142	142	1	64	-28.75
143	143	1	64	-85.8125
144	144	1	64	-34.71875
145	145	46	2944	-5723.25
146	146	8	512	-471.34375
147	147	1	64	-55.484375
148	148	2	128	-17.34375
149	149	3	192	-151.15625
150	150	26	1664	-1991.3125
151	151	1	64	3.71875
152	152	1	64	-7.078125
153	153	2	128	116.171875
154	154	1	64	-27.546875
155	155	3668	234752	-3324295.766
156	156	1	64	-79.71875
157	157	1	64	-20.125
158	158	1	64	2.890625
159	159	2	128	55.015625
160	160	2	128	-42.1875
161	161	18	1152	-974.875
162	162	2	128	-152.671875
163	163	2	128	-3.125
164	164	43	2752	-4039.640625
165	165	1	64	-14.015625
166	166	2	128	-36.453125
167	167	3484	222976	-2270951.156
168	168	6	384	-54.078125
169	169	234	14976	-34342.5625
170	170	9	576	-114.125
171	171	1	64	17.46875
172	172	68	4352	-13464.57813
173	173	1	64	-1.90625
174	174	62	3968	-7481.625
175	175	3	192	136.09375
176	176	1	64	89.515625
177	177	56	3584	-9611.59375
178	178	2	128	-29.40625
179	179	1	64	12.578125
180	180	1	64	-38.859375
181	181	1	64	-105.28125
182	182	1	64	14.40625
183	183	1	64	33.265625
184	184	33	2112	1147.75

OBJECTID *	Value	Count	AREA	VOLUME	
185	185	5050	323200	-4634104.781	
186	186	10	640	-134.421875	
187	187	1	64	2.015625	
188	188	572	36608	-138182.0313	
189	189	3	192	-53.5	
190	190	13	832	823.28125	
191	191	1	64	26.40625	
192	192	1	64	-23.296875	
193	193	35	2240	-6541.53125	
194	194	1	64	49.171875	
195	195	3	192	104.140625	
196	196	9	576	376.921875	
197	197	1	64	7.484375	
198	198	1	64	4.734375	
199	199	2	128	40.9375	
200	200	33	2112	2361.015625	
201	201	1	64	25.359375	
202	202	415	26560	-102294.6875	
203	203	2	128	-48.9375	
204	204	1	64	-9.90625	
205	205	3	192	-82.796875	
206	206	1	64	-1.203125	
207	207	3	192	30.53125	
208	208	11	704	-330.390625	
209	209	1	64	9.109375	
210	210	3	192	-89.71875	
211	211	6	384	-148.296875	
212	212	1	64	-25.296875	
213	213	2	128	89.515625	
214	214	10	640	482.25	
215	215	4	256	31.59375	
216	216	1	64	-11.890625	
217	217	31	1984	-4014.78125	
218	218	2	128	-98.8125	
219	219	67	4288	-14697.65625	
220	220	1	64	-41.4375	
221	221	6	384	-247.578125	
222	222	66	4224	-6423.5	
223	223	1	64	-34.84375	
224	224	143	9152	-24874.15625	
225	225	3	192	-102.625	
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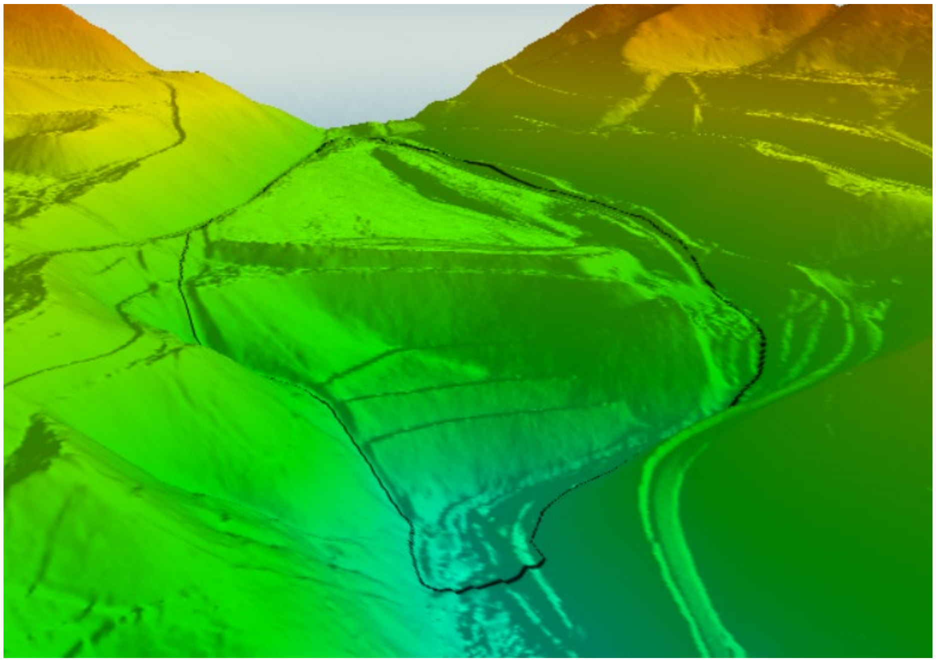
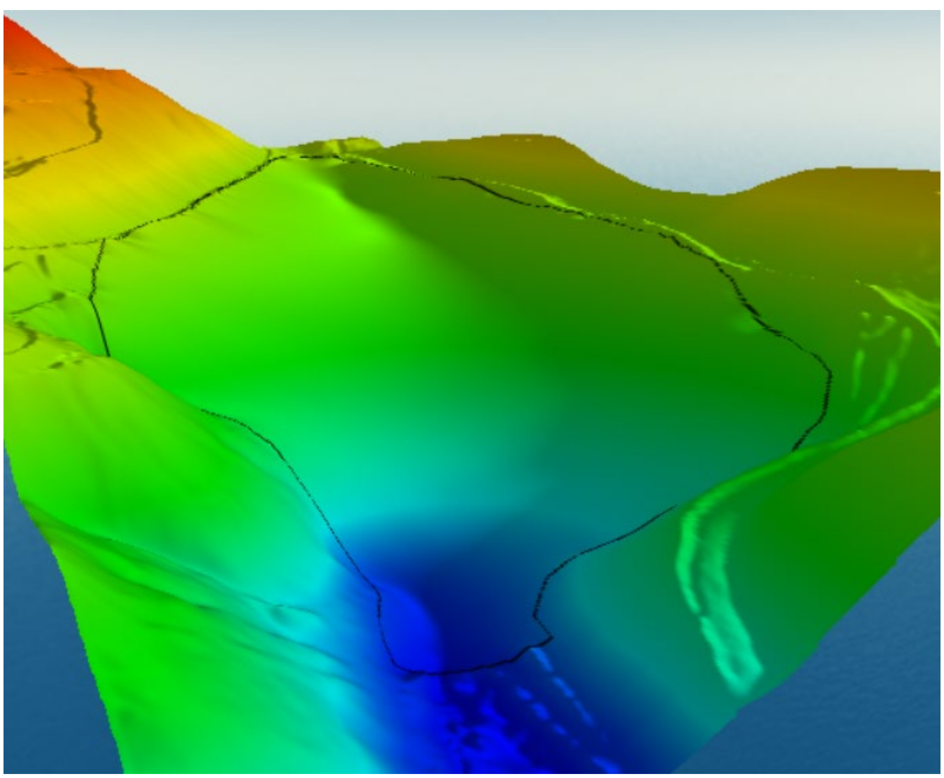
				4525138.947	CY

Unique ID: GEM_72122557

Current Surface:



Historical Surface:



Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

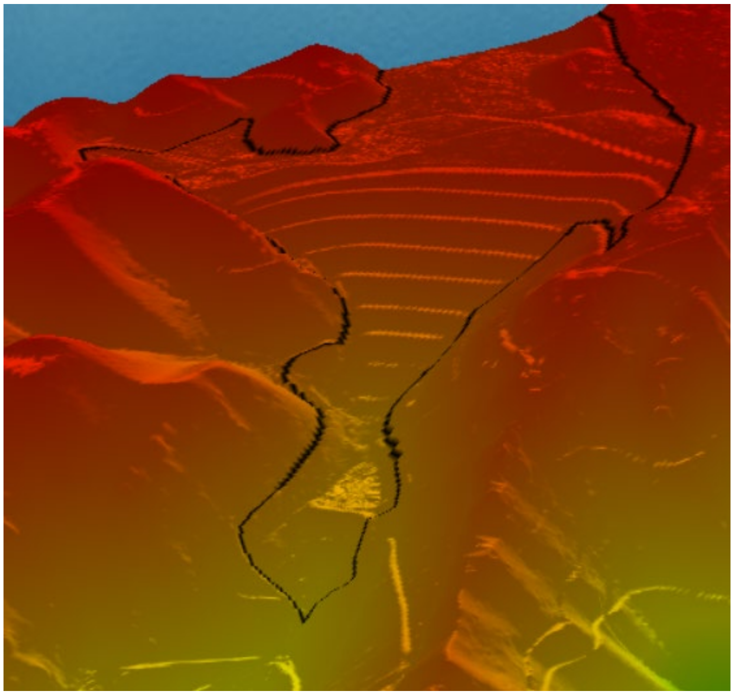
OBJECTID *	Value	Count	AREA	VOLUME
1	1	5535	59578.00584	-205405.467
2	2	1	10.763867	2.081295
3	3	4	43.055469	28.975196
4	4	3	32.291602	27.345899
5	5	4	43.055469	24.484119
6	6	12	129.166408	107.052653
7	7	3	32.291602	12.976557
8	8	1	10.763867	0.580765
9	9	137158	1476350.52	33350550.92
10	10	2	21.527735	9.09778
11	11	2	21.527735	5.32412
12	12	3	32.291602	9.36057
13	13	1	10.763867	3.447801
14	14	3	32.291602	1.571483
15	15	1	10.763867	1.390158
16	16	2	21.527735	0.946043
17	17	2	21.527735	3.581824
18	18	3	32.291602	4.922052
19	19	5	53.819337	7.959901
20	20	1	10.763867	1.172042
21	21	42	452.082429	-130.230707
22	22	1	10.763867	0
23	23	17	182.985745	-38.535486
24	24	1	10.763867	-0.754207
25	25	4	43.055469	-5.22426
26	26	1	10.763867	-1.495274
27	27	1	10.763867	-0.906625
28	28	28	301.388286	-52.883805
29	29	1	10.763867	0.530835
30	30	1	10.763867	-1.445344
31	31	3	32.291602	-3.242825
32	32	3	32.291602	-5.513329
33	33	80	861.109389	-830.846524
34	34	12	129.166408	-18.818373
35	35	2	21.527735	-10.353915
36	36	56	602.776572	-168.0698
37	37	10	107.638674	-50.463512
38	38	1	10.763867	0
39	39	2	21.527735	4.577797
40	40	13	139.930276	-36.175634
41	41	1	10.763867	0
42	42	3	32.291602	-4.927307
43	43	1	10.763867	-1.032764
44	44	1	10.763867	-0.475649
45	45	1	10.763867	5.910141
46	46	44	473.610164	-186.538662
47	47	1	10.763867	0
48	48	2	21.527735	5.52384
49	49	5547	59707.17225	-205538.8933

OBJECTID *	Value	Count	AREA	VOLUME
50	50	1	10.763867	1.203577
51	51	1	10.763867	-0.183953
52	52	1	10.763867	-0.906625
53	53	4	43.055469	-18.277026
54	54	3	32.291602	-11.21061
55	55	1	10.763867	-0.743695
56	56	4	43.055469	-21.425247
57	57	1	10.763867	-0.801509
58	58	1	10.763867	-0.620184
59	59	1	10.763867	-0.667486
60	60	10	107.638674	-61.387681
61	61	1	10.763867	-2.932733
62	62	3	32.291602	22.657731
63	63	1	10.763867	-3.22443
64	64	2	21.527735	-7.029625
65	65	1	10.763867	-2.181155
66	66	1	10.763867	-1.976179
67	67	1	10.763867	-1.963039
68	68	2	21.527735	-3.142965
69	69	11	118.402541	-36.814213
70	70	10	107.638674	-47.133966
71	71	17	182.985745	-52.108576
72	72	1	10.763867	-0.430975
73	73	19	204.51348	-91.201176
74	74	1	10.763867	2.189038
75	75	7	75.347072	26.473437
76	76	1	10.763867	0.488789
77	77	3	32.291602	3.334802
78	78	4	43.055469	-13.82274
79	79	1	10.763867	1.823761
80	80	2	21.527735	2.690967
81	81	1	10.763867	-6.396302
82	82	9	96.874806	-51.057417
83	83	9	96.874806	41.318429
84	84	2	21.527735	-8.785061
85	85	1	10.763867	-4.194124
86	86	3	32.291602	-13.870042
87	87	6	64.583204	6.041536
88	88	8	86.110939	-57.017488
89	89	402	4327.074679	9886.12601
90	90	6	64.583204	-54.024313
91	91	9	96.874806	-49.914281
92	92	7	75.347072	25.564185
93	93	1	10.763867	0.136651
94	94	28	301.388286	189.41621
95	95	3	32.291602	9.147711
96	96	77	828.817787	386.561066
97	97	7	75.347072	-34.701384
98	98	1	10.763867	-0.102488

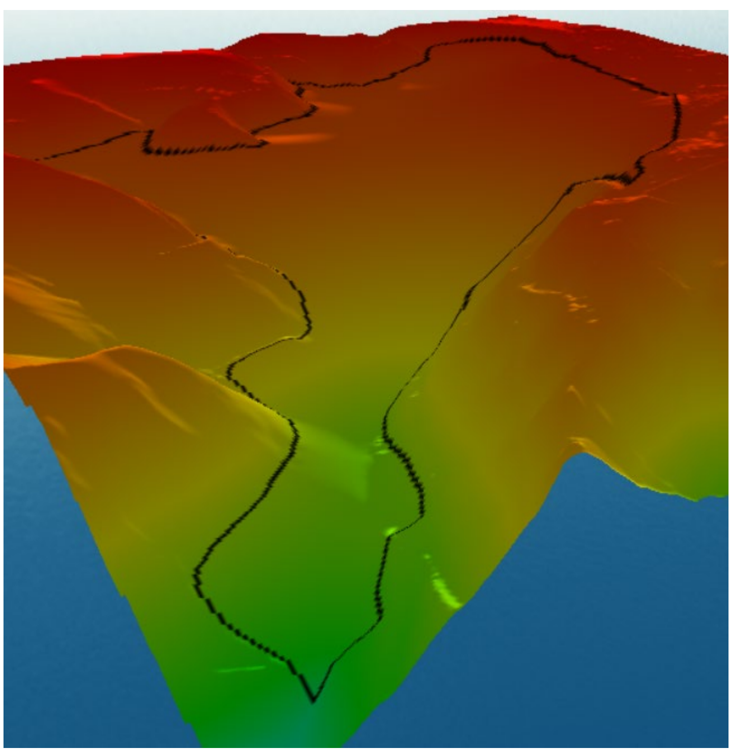
OBJECTID *	Value	Count	AREA	VOLUME
99	99	19	204.51348	-98.380591
100	100	2	21.527735	-1.508413
101	101	22	236.805082	-77.911899
102	102	12	129.166408	-41.031989
103	103	8	86.110939	-27.871479
104	104	5	53.819337	-14.519133
105	105	1	10.763867	1.253507
106	106	1	10.763867	-0.693765
107	107	9	96.874806	-36.680191
108	108	3	32.291602	-5.408213
109	109	1059	11398.93554	-44513.7501
110	110	1	10.763867	-0.19972
111	111	1	10.763867	1.57411
112	112	2	21.527735	-5.518584
113	113	60	645.832042	618.383654
114	114	15	161.45801	32.102393
115	115	1	10.763867	0.113
116	116	1	10.763867	5.954815
117	117	22	236.805082	-164.177884
118	118	2	21.527735	8.322551
119	119	3	32.291602	4.375449
120	120	12	129.166408	91.484989
121	121	12	129.166408	-32.165463
122	122	2	21.527735	-9.760011
123	123	2	21.527735	-11.741445
124	124	26	279.860551	278.128767
125	125	97	1044.095134	-756.674122
126	126	1	10.763867	5.360911
127	127	9	96.874806	30.890933
128	128	7	75.347072	46.789712
129	129	1	10.763867	2.015597
130	130	14	150.694143	104.797917
131	131	8	86.110939	-10.246172
132	132	26	279.860551	-93.794911
133	133	2	21.527735	-2.031365
134	134	7	75.347072	-55.929538
135	135	13	139.930276	-65.881385
136	136	8	86.110939	-40.708757
				32903437.33 CF
				1218645 CY

Unique ID: GEM_72122640

Current Surface:



Historical Surface:



Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	92305	1476880	22329212.57
2	2	1	16	-1.773438
3	3	4	64	-7.339844
4	4	2	32	-4.714844
5	5	17	272	-73.152344
6	6	1	16	8.132813
7	7	25	400	-159.914063
8	8	91	1456	-1207.054688
9	9	16	256	-73.597656
10	10	15	240	-115.054688
11	11	229	3664	-2523.453125
12	12	1	16	-6.390625
13	13	1	16	-3.597656
14	14	1	16	-0.945313
15	15	5	80	-47.398438
16	16	3	48	3.664063
17	17	15	240	-116.933594
18	18	1	16	-4.714844
19	19	1	16	17.035156
20	20	1	16	-0.085938
21	21	1	16	-1.417969
22	22	4	64	-3.855469
23	23	1	16	-1.5625
24	24	17900	286400	-1649314.324
25	25	1	16	-0.535156
26	26	1	16	-8.457031
27	27	1	16	2.21875
28	28	1	16	0.703125
29	29	203	3248	-4015.277344
30	30	1	16	1.835938
31	31	1	16	-3.847656
32	32	1	16	-2.320313
33	33	15	240	-61.136719
34	34	1	16	-5.824219
35	35	11	176	-113.679688
36	36	1	16	0.503906
37	37	1	16	0
38	38	1	16	-0.152344
39	39	18	288	-72.148438
40	40	1	16	2.277344
41	41	1	16	-0.289063
42	42	3	48	-6.710938
43	43	5	80	-20.644531
44	44	1	16	-0.785156
45	45	22	352	-258.15625
46	46	14	224	86.640625

OBJECTID *	Value	Count	AREA	VOLUME
47	47	61	976	-409.132813
48	48	3	48	6.953125
49	49	1	16	-2.050781
50	50	2459	39344	-253991.9258
51	51	2	32	-2.746094
52	52	1	16	0.710938
53	53	1	16	5.140625
54	54	6	96	-40.605469
55	55	1	16	-0.277344
56	56	2	32	12.074219
57	57	1	16	0
58	58	152	2432	-2297.4375
59	59	1	16	-0.714844
60	60	1	16	-0.660156
61	61	3	48	-4.851563
62	62	2	32	-12.078125
63	63	72	1152	-473.890625
64	64	1	16	-4.996094
65	65	1	16	-0.996094
66	66	1	16	-1.613281
67	67	1	16	-1.445313
68	68	1	16	0.515625
69	69	1	16	2.246094
70	70	3	48	-7.355469
71	71	7	112	-22.738281
72	72	11	176	-114.664063
73	73	133	2128	-1275.929687
74	74	1	16	3.148438
75	75	6	96	-77.578125
76	76	1	16	-3.941406
77	77	254	4064	-4625.371094
78	78	4	64	-4.699219
79	79	5	80	-5.785156
80	80	7	112	-9
81	81	4	64	22.988281
82	82	2	32	-1.550781
83	83	1	16	-0.964844
84	84	6	96	-8.621094
85	85	2	32	11.121094
86	86	16777	268432	-2653765.93
87	87	6	96	244.914063
88	88	3	48	25
89	89	11	176	135.183594
90	90	51	816	439.476563
91	91	2	32	-0.625
92	92	1	16	-4.097656

OBJECTID *	Value	Count	AREA	VOLUME
93	93	3	48	3.046875
94	94	2	32	14.925781
95	95	976	15616	-87456.46484
96	96	1	16	1.472656
97	97	1	16	0.023438
98	98	3	48	16.884766
99	99	3	48	-7.429688
100	100	48	768	458.59375
101	101	1	16	0.15625
102	102	2	32	-5.625
103	103	5	80	-18.132813
104	104	4	64	19.945313
105	105	1	16	-0.035156
106	106	1	16	0.921875
107	107	1	16	12.029297
108	108	7	112	-34.035156
109	109	2	32	12.34375
110	110	3	48	-11.535156
111	111	112	1792	-2319.867188
112	112	1	16	-2.113281
113	113	1	16	-0.980469
114	114	1	16	-0.648438
115	115	86	1376	-1651.472656
116	116	1	16	-2.082031
117	117	130	2080	-1577.982422
118	118	1	16	4.898438
119	119	1	16	-4.179688
120	120	2	32	-10.582031
121	121	1	16	1.597656
122	122	1	16	-1.226563
123	123	1	16	4.742188
124	124	1	16	-10.613281
125	125	157	2512	-2475.431641
126	126	7	112	-16.859375
127	127	3	48	-14.519531
128	128	2	32	-3.46875
129	129	5	80	-28.068359
130	130	1	16	0.691406
131	131	33	528	-615.359375
132	132	2269	36304	186335.5547
133	133	1	16	-0.496094
134	134	3	48	-7.402344
135	135	166	2656	-5895.814453
136	136	3	48	23.699219
137	137	2	32	-9.449219
138	138	1	16	-28.285156

OBJECTID *	Value	Count	AREA	VOLUME
139	139	97	1552	-2638.6875
140	140	3	48	-25.101563
141	141	2	32	-1.320313
142	142	1	16	-0.369141
143	143	1	16	-0.75
144	144	2	32	-9.371094
145	145	26	416	249.570313
146	146	52	832	-714.710938
147	147	1	16	15.523438
148	148	58	928	825.472656
149	149	3	48	20.023438
150	150	4	64	9.003906
151	151	2	32	-16.851563
152	152	1	16	4.714844
153	153	1	16	13.773438
154	154	1	16	1.988281
155	155	2	32	-12.664063
156	156	3	48	-43.691406
157	157	12	192	121.025391
158	158	3	48	36.808594
159	159	1	16	9.048828
160	160	1	16	17.453125
161	161	1	16	2.337891
162	162	68	1088	-2335.921875
163	163	79	1264	1089.753906
164	164	1	16	-0.154297
165	165	1	16	-0.527344
166	166	3	48	-23.806641
167	167	29	464	-449.46875
168	168	149	2384	-4030.894531
169	169	435	6960	17418.0293
170	170	5	80	8.611328
171	171	2	32	3.683594
172	172	1	16	0.029297
173	173	1	16	-0.703125
174	174	2	32	5.777344
175	175	15	240	206.167969
176	176	2	32	13.396484
177	177	1	16	5.019531
178	178	6	96	39.816406
179	179	6	96	-39.753906
180	180	5	80	53.890625
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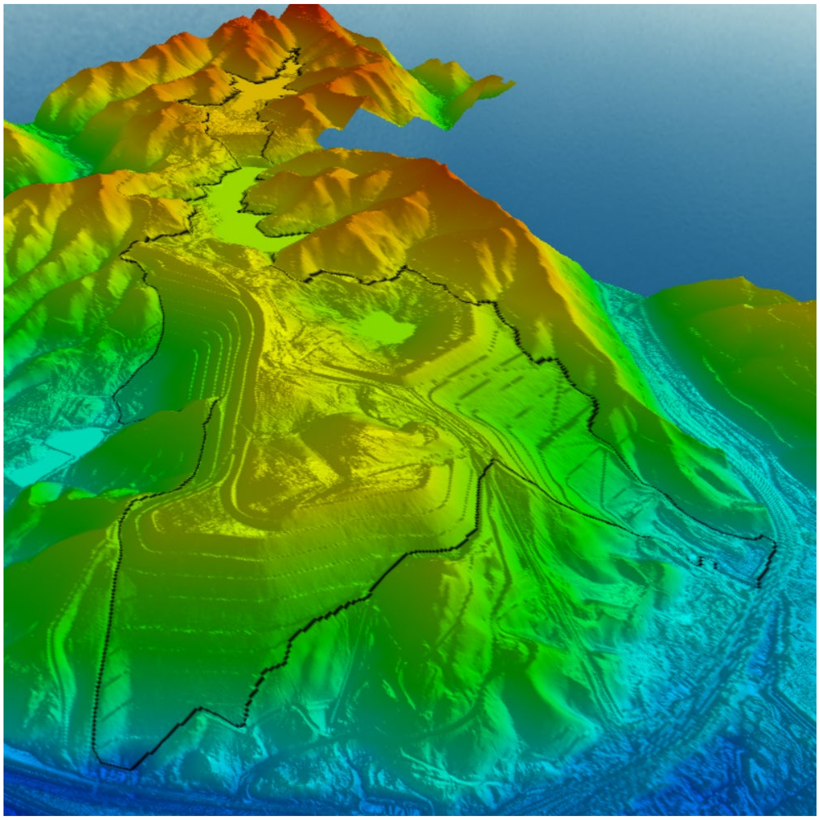
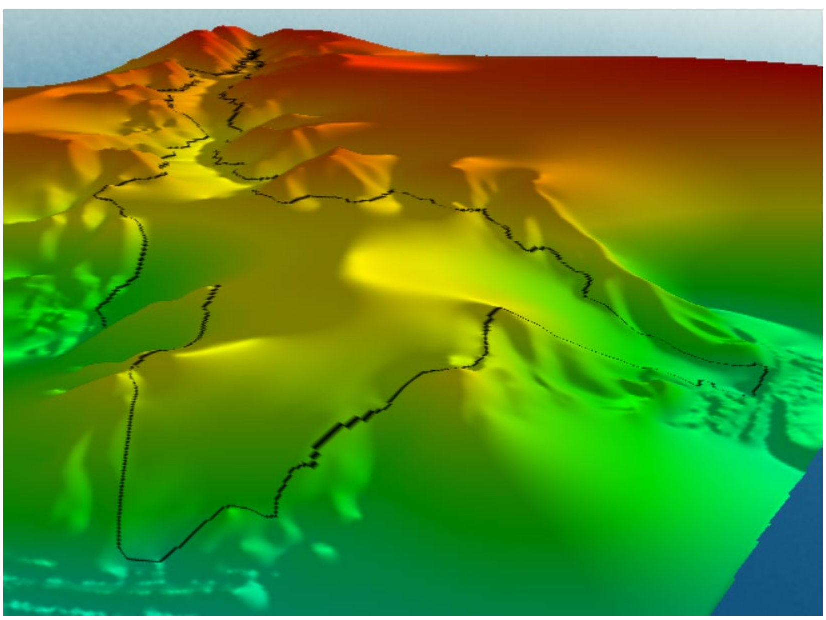
661087 CY

Unique ID: GEM_72222156

Current Surface:



Historical Surface:



Process Documentation:
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OBJECTID *	Value	Count	AREA	VOLUME
1	1	240	126960	-323119.9417
2	2	1	529	0.645752
3	3	1	529	31.512695
4	4	1	529	47.656494
5	5	12	6348	2375.721436
6	6	1	529	112.748291
7	7	10	5290	-9201.707031
8	8	1	529	71.032715
9	9	1	529	733.83252
10	10	6	3174	-4984.042725
11	11	2	1058	1838.843262
12	12	5	2645	-7963.800537
13	13	1	529	-905.085938
14	14	5941	3142789	38009264.82
15	15	18	9522	-23405.79614
16	16	7	3703	-5882.800293
17	17	8	4232	-4369.286865
18	18	5	2645	-4347.5896
19	19	23	12167	-18576.47559
20	20	1	529	-1111.984863
21	21	43	22747	-82135.38648
22	22	8	4232	-9243.164307
23	23	33	17457	-51359.62329
24	24	50	26450	-66842.43042
25	25	12	6348	-9756.407959
26	26	2	1058	-2554.723877
27	27	1	529	-1331.798828
28	28	13	6877	-24656.35938
29	29	1	529	378.152344
30	30	10	5290	-11196.95142
31	31	55	29095	-34818.94531
32	32	1	529	55.922119
33	33	1	529	-192.046631
34	34	15	7935	-19969.10425
35	35	53	28037	-71624.61108
36	36	1	529	692.762695
37	37	1	529	831.986816
38	38	7	3703	-8359.259033
39	39	108	57132	-144678.917
40	40	3	1587	-1231.965576
41	41	2	1058	-1125.287354
42	42	4	2116	-4936.38623
43	43	9	4761	-13811.73023
44	44	99	52371	-308316.7239
45	45	1	529	-144.906738
46	46	3	1587	2418.857666

OBJECTID *	Value	Count	AREA	VOLUME
47	47	89	47081	-144307.2222
48	48	109	57661	-199447.5294
49	49	4	2116	2017.199951
50	50	1	529	2.260132
51	51	3	1587	645.687378
52	52	3	1587	-3522.641479
53	53	1	529	-2136.018311
54	54	21152	11189408	473528386
55	55	1	529	319.001465
56	56	355	187795	-780226.2457
57	57	2	1058	-3037.229736
58	58	2	1058	-2223.840576
59	59	2	1058	761.664429
60	60	463	244927	-1496511.166
61	61	3	1587	3827.178101
62	62	1	529	2090.040771
63	63	3	1587	6318.489136
64	64	2	1058	1856.47229
65	65	2	1058	1360.857666
66	66	2	1058	436.011719
67	67	1	529	839.800415
68	68	5	2645	4931.607666
69	69	2	1058	7504.670898
70	70	11	5819	-11599.57776
71	71	1	529	-206.382324
72	72	5	2645	-5119.71521
73	73	14	7406	12334.63721
74	74	61	32269	-151836.7545
75	75	2397	1268013	-38589026.41
76	76	4	2116	-4321.307495
77	77	69	36501	-126785.1304
78	78	1	529	-11.752686
79	79	4	2116	2441.65271
80	80	4	2116	533.455688
81	81	2	1058	759.662598
82	82	2	1058	-1912.717285
83	83	47	24863	-100986.8878
84	84	39	20631	-117246.6637
85	85	2	1058	216.585205
86	86	12	6348	6762.89563
87	87	1	529	996.588989
88	88	26	13754	-47490.21301
89	89	2	1058	520.476074
90	90	205	108445	-689803.989
91	91	3	1587	3766.541992
92	92	3	1587	-5505.164551

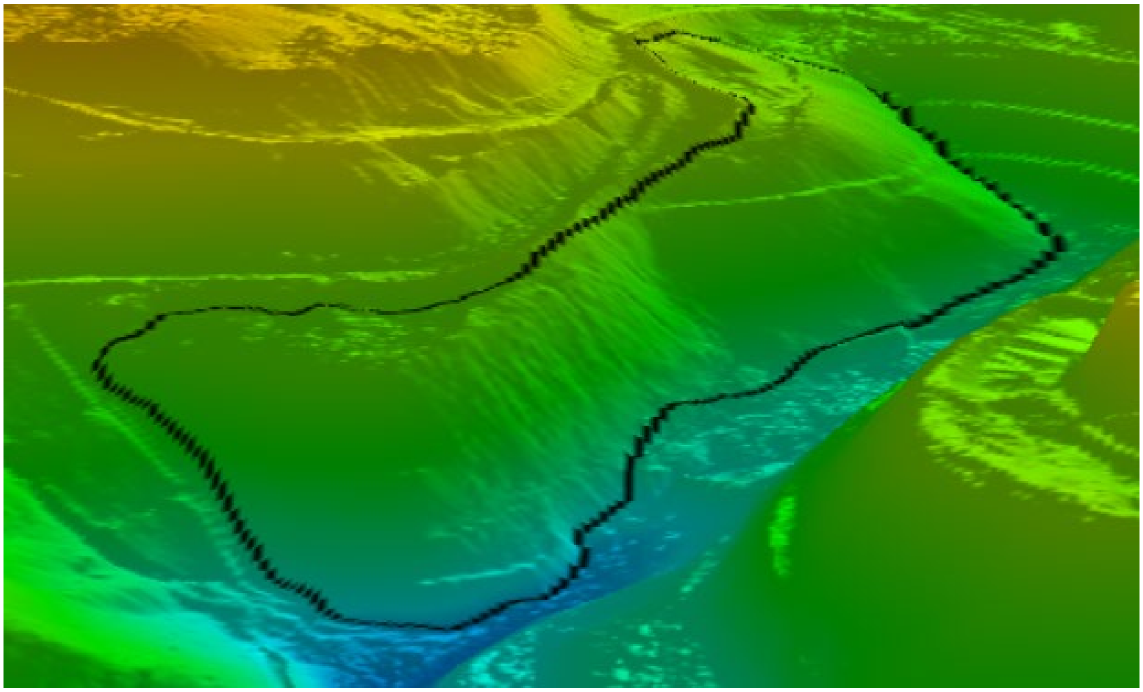
OBJECTID *	Value	Count	AREA	VOLUME
93	93	9	4761	-27294.83728
94	94	1	529	-416.832886
95	95	97	51313	200044.0751
96	96	1	529	-107.5177
97	97	251	132779	-1168938.313
98	98	19	10051	-46990.1427
99	99	1	529	306.796753
100	100	7	3703	3589.089355
101	101	2	1058	1665.781738
102	102	1	529	669.773926
103	103	1	529	151.622559
104	104	2157	1141053	-21270618.73
105	105	1	529	-760.889526
106	106	3	1587	-1094.355835
107	107	2	1058	-1407.158081
108	108	6	3174	5025.62915
109	109	339	179331	1278669.586
110	110	6	3174	-19382.11572
111	111	15	7935	-27646.51379
112	112	53	28037	76628.34924
113	113	3	1587	-1693.161621
114	114	1	529	145.55249
115	115	14	7406	6835.930176
116	116	4	2116	1183.53418
117	117	1	529	-81.235596
118	118	8	4232	-3434.238037
119	119	1	529	1200.969482
120	120	1	529	119.270386
121	121	5	2645	4629.718628
122	122	1	529	884.034424
123	123	1	529	688.048706
124	124	21	11109	20175.03455
125	125	1	529	809.514648
126	126	73	38617	-187935.7094
127	127	1	529	1007.179321
128	128	1	529	1929.765137
129	129	3	1587	-283.678833
130	130	1	529	861.433105
131	131	9	4761	-6033.841675
132	132	2	1058	868.988403
133	133	1	529	14.400269
134	134	2	1058	2019.008057
135	135	3	1587	3683.885742
136	136	2	1058	-2998.549194
137	137	1	529	-388.742676
138	138	2	1058	-2844.924805

OBJECTID *	Value	Count	AREA	VOLUME
139	139	28	14812	-44274.36829
140	140	3	1587	-2615.037109
141	141	14	7406	-27565.73023
142	142	3	1587	-2024.496948
143	143	1	529	-969.209106
144	144	4	2116	-1859.055298
145	145	3	1587	-4160.90271
146	146	1	529	-275.542358
147	147	2	1058	-621.019653
148	148	2	1058	-866.34082
149	149	4	2116	-5443.75354
150	150	60	31740	-128801.9429
151	151	1	529	1488.716553
152	152	1	529	-49.141724
153	153	1	529	1515.256958
154	154	1	529	-60.958984
155	155	20	10580	-23034.87622
156	156	3	1587	-1701.168945
157	157	3	1587	-3108.262451
158	158	4	2116	-2089.52417
159	159	1	529	-266.308105
160	160	1	529	-1135.167358
161	161	1	529	-107.776001
162	162	1	529	-273.346802
163	163	3	1587	-1663.650757
164	164	1	529	-14.464844
165	165	6	3174	-5769.987427
166	166	3	1587	-2300.878784
167	167	1	529	95.571289
168	168	171	90459	-428404.6962
169	169	1	529	293.558838
170	170	80	42320	-125881.2714
171	171	1	529	70.709839
172	172	2	1058	1175.591431
173	173	10	5290	14156.10974
174	174	2	1058	2202.918213
175	175	1	529	984.448853
176	176	2	1058	-1449.77771
177	177	6	3174	-2969.490356
178	178	44	23276	-41055.0365
179	179	3	1587	189.851074
180	180	3	1587	-3919.585205
181	181	69	36501	-72051.96973
182	182	1	529	-398.622681
183	183	2	1058	-1712.211304
184	184	1	529	94.860962

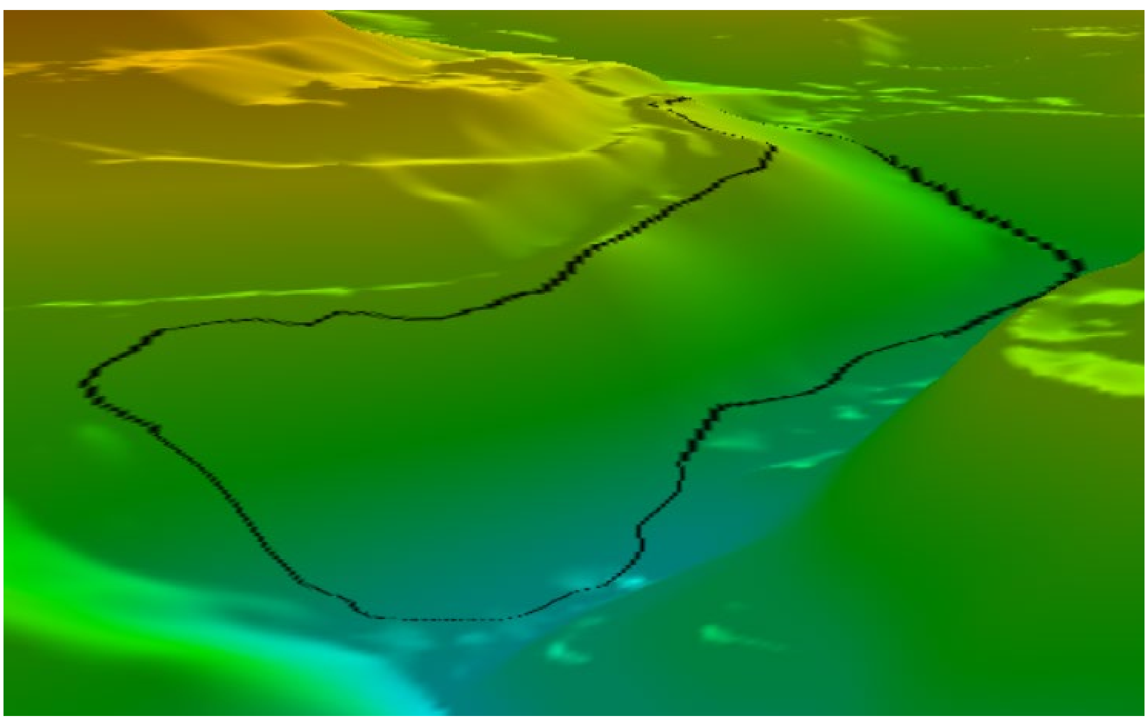
OBJECTID *	Value	Count	AREA	VOLUME	
185	185	3	1587	-1534.500366	
186	186	6	3174	-4179.694092	
187	187	2	1058	-6928.078979	
188	188	421	222709	-1530508.263	
189	189	1	529	-27.896484	
190	190	1	529	200.053955	
191	191	2	1058	-1654.73938	
192	192	5	2645	4208.817505	
193	193	1	529	164.020996	
194	194	11	5819	16123.00562	
195	195	4	2116	1570.5979	
196	196	8	4232	14602.45349	
197	197	8	4232	13573.51233	
198	198	1	529	34.224854	
199	199	1	529	1138.525269	CF
				444286673.6	
				16455061	CY

Unique ID: GEM_72722430

Current Surface:



Historical Surface:



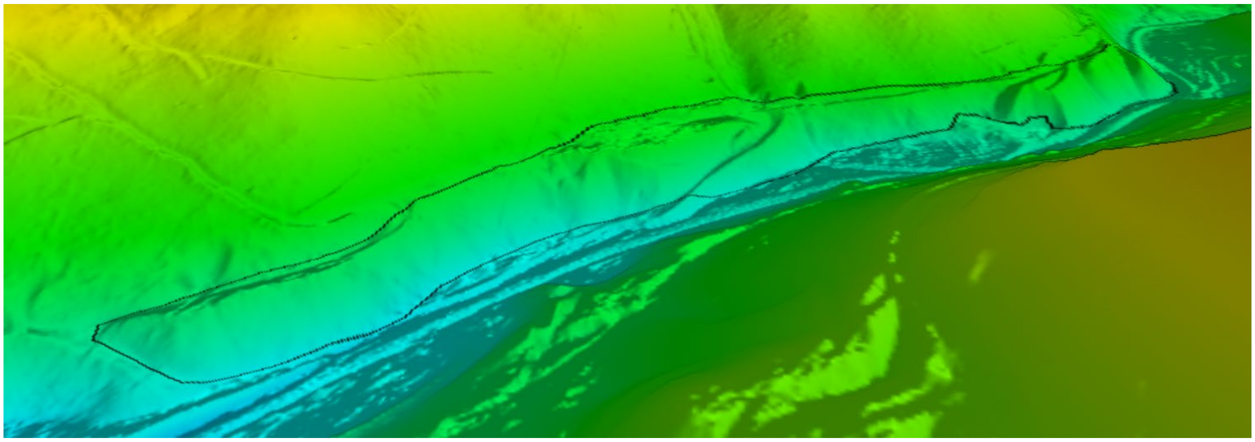
Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	3	300	-243.664551
2	2	2482	248200	3934532.21
3	3	1055	105500	-809425.269
4	4	1	100	-52.807617
5	5	2	200	-272.961426
6	6	2	200	-90.380859
7	7	1	100	-11.877441
8	8	1	100	-2.539063
9	9	1	100	-96.630859
10	10	3	300	255.102539
11	11	1	100	-26.660156
12	12	1	100	-88.220215
13	13	1	100	-24.841309
14	14	6	600	-310.15625
15	15	1	100	-16.357422
16	16	3	300	-170.568848
17	17	1	100	-23.742676
18	18	2	200	-35.36377
19	19	2	200	-140.29541
20	20	1	100	-83.862305
21	21	1	100	-57.312012
22	22	2	200	-212.365723
23	23	1	100	-151.977539
24	24	1	100	-50.805664
25	25	1603	160300	4575433.75
26	26	12	1200	1073.33984
27	27	18	1800	-1897.68066
28	28	2	200	-277.990723
29	29	1	100	-71.228027
30	30	1	100	126.062012
31	31	1	100	-11.560059
32	32	1	100	-209.460449
33	33	1	100	-27.868652
34	34	3	300	-420.776367
35	35	1	100	-162.268066
36	36	2	200	-29.016113
37	37	1	100	-16.442871
38	38	2	200	-117.541504
39	39	1	100	-48.413086
				7696541.56 CF

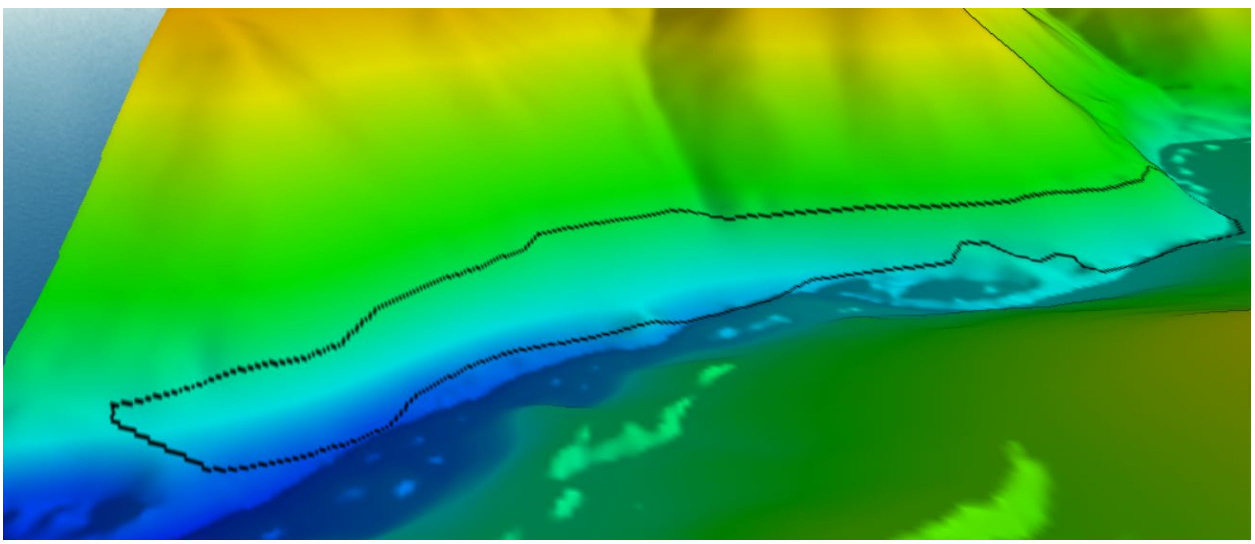
285057 CY

Unique ID: GEM_82422343

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

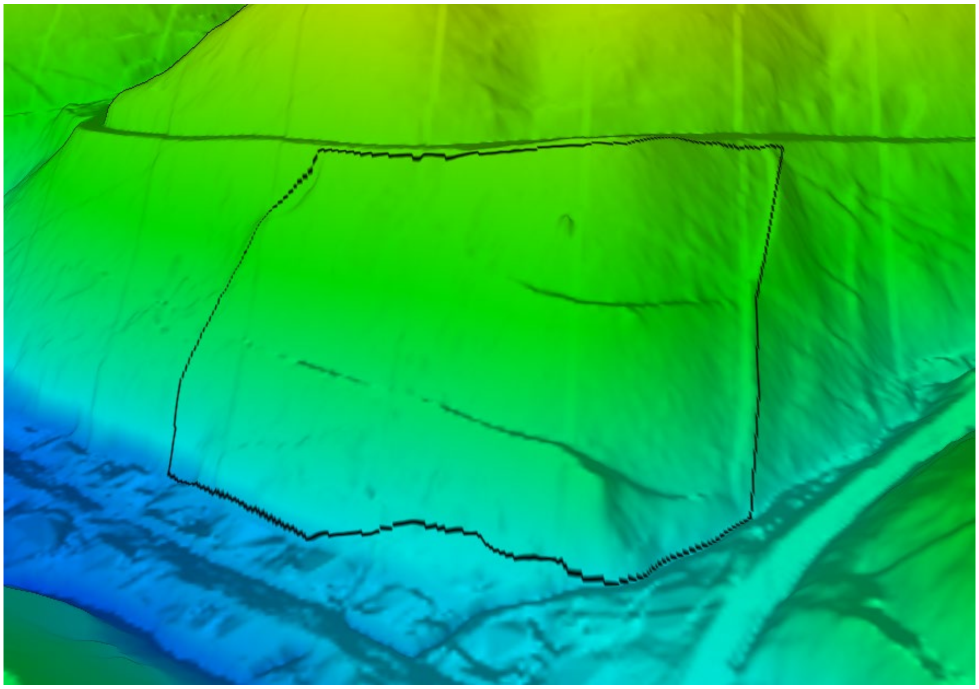
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

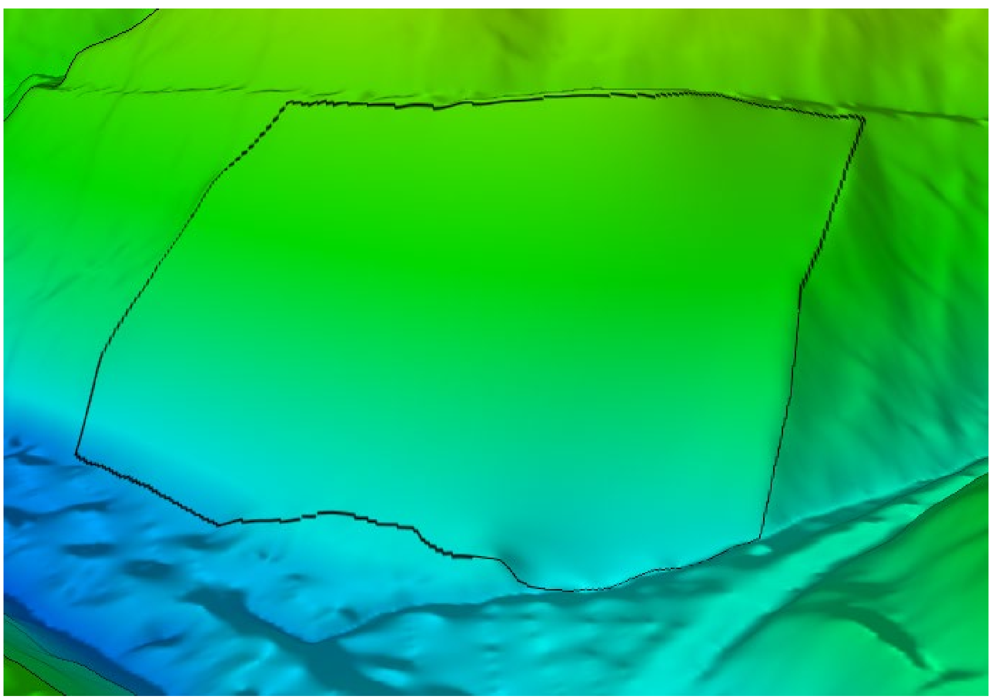
Rowid	VALUE	COUNT	AREA	VOLUME	
0	1	75	3675	-9535.105713	
1	2	4695	230055	3708306.069	
2	3	1	49	-9.223389	
3	4	1	49	-17.106934	
4	5	2	98	-51.392578	
5	6	2	98	-22.394531	
6	7	2	98	-69.312988	
7	8	4	196	-161.080322	
8	9	1	49	-10.946045	
9	10	22	1078	-1798.14209	
10	11	16	784	-1042.392456	
11	12	2	98	-108.682861	
				3695480.289	CF
				136869	CY

Unique ID: GEM_82622643

Current Surface:



Historical Surface:



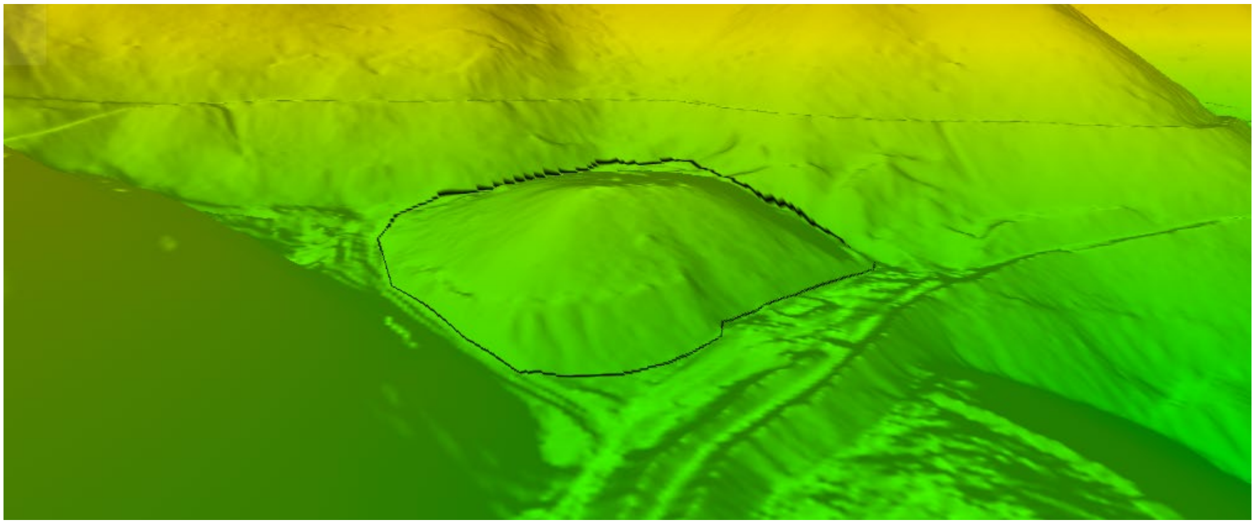
Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

Rowid	VALUE	COUNT	AREA	VOLUME
0	1	1	10.763867	8.267365
1	2	7	75.347072	28.696639
2	3	674	7254.846601	-12058.52593
3	4	1	10.763867	3.112744
4	5	28	301.388286	199.291848
5	6	5	53.819337	43.159271
6	7	2	21.527735	2.087864
7	8	2	21.527735	-12.652012
8	9	7584	81633.17007	681356.6157
9	10	3	32.291602	-15.382397
10	11	1	10.763867	1.246937
11	12	1	10.763867	2.221887
12	13	2	21.527735	-17.923574
13	14	1	10.763867	0.345568
14	15	1	10.763867	-0.41915
15	16	3	32.291602	9.099094
16	17	1	10.763867	-0.760776
17	18	1	10.763867	1.959097
18	19	1	10.763867	0.734497
19	20	2	21.527735	-6.931079
20	21	1	10.763867	-1.664773
21	22	1	10.763867	-3.257279
22	23	5	53.819337	-17.742249
23	24	9	96.874806	-26.830831
24	25	1	10.763867	0.09329
25	26	1	10.763867	-2.426863
26	27	4	43.055469	-21.313561
27	28	1	10.763867	-2.24291
28	29	1	10.763867	-1.408553
29	30	1	10.763867	-0.304836
30	31	1	10.763867	-3.884032
31	32	757	8148.247592	-13511.92002
32	33	18	193.749612	-57.234289
33	34	1	10.763867	3.312465
34	35	1	10.763867	3.859067
35	36	3	32.291602	5.602677
36	37	4	43.055469	-22.054628
37	38	1	10.763867	-0.053872
38	39	4	43.055469	-11.20404
39	40	3	32.291602	-4.802482
40	41	2	21.527735	-4.932563
41	42	19	204.51348	-140.84347
42	43	12	129.166408	70.540647
43	44	1	10.763867	-4.015427
44	45	2	21.527735	-18.508281
45	46	1	10.763867	3.792056

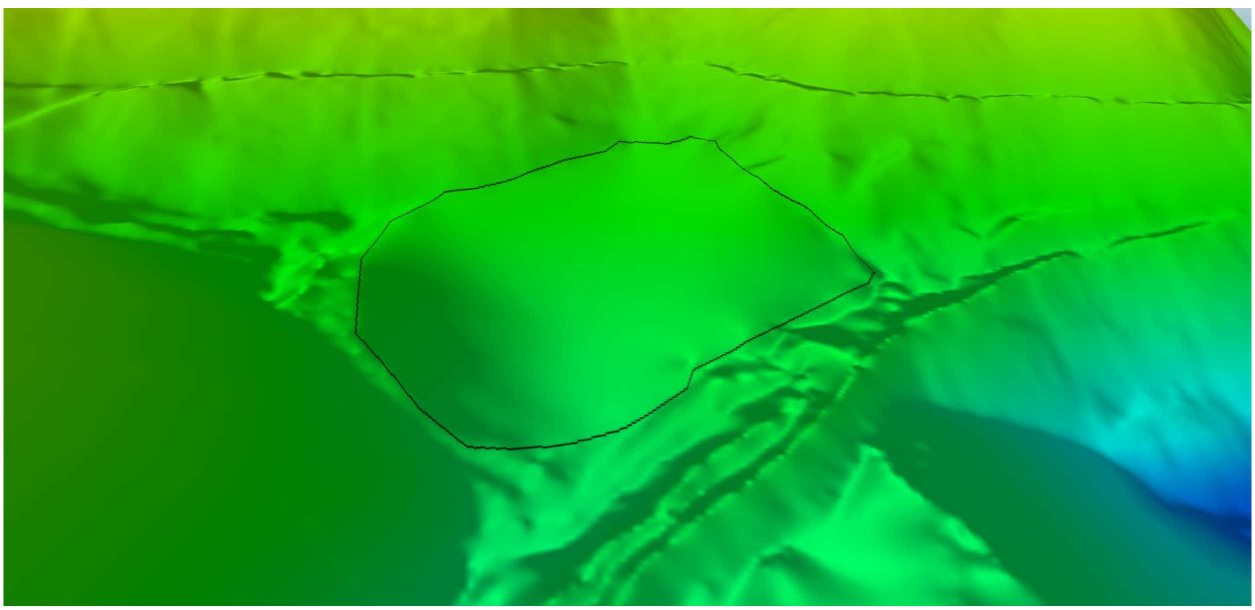
Rowid	VALUE	COUNT	AREA	VOLUME	
46	47	2	21.527735	-18.27834	
47	48	1	10.763867	-9.229175	
48	49	4	43.055469	-35.606695	
49	50	5	53.819337	-26.445845	
50	51	6	64.583204	-40.791536	
51	52	1	10.763867	-3.171872	
52	53	12	129.166408	-71.053087	
53	54	94	1011.803532	-963.588186	
				654606.6341	CF
				24245	CY

Unique ID: GEM_82622713

Current Surface:



Historical Surface:

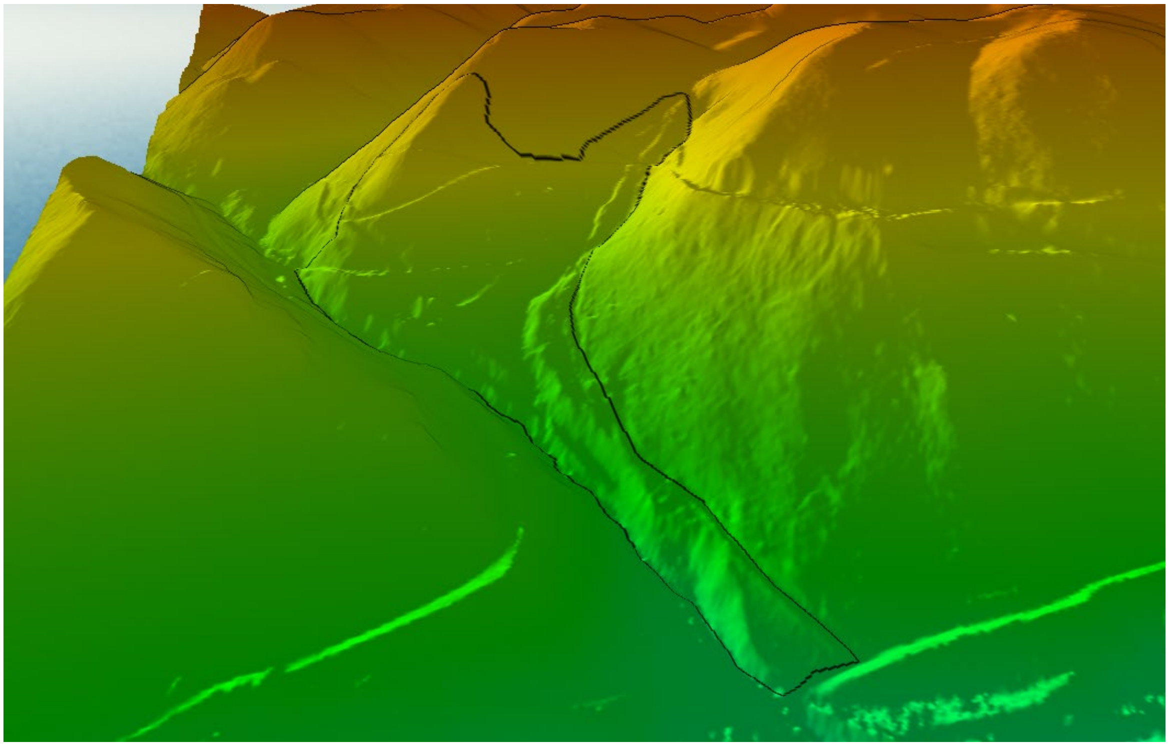


Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

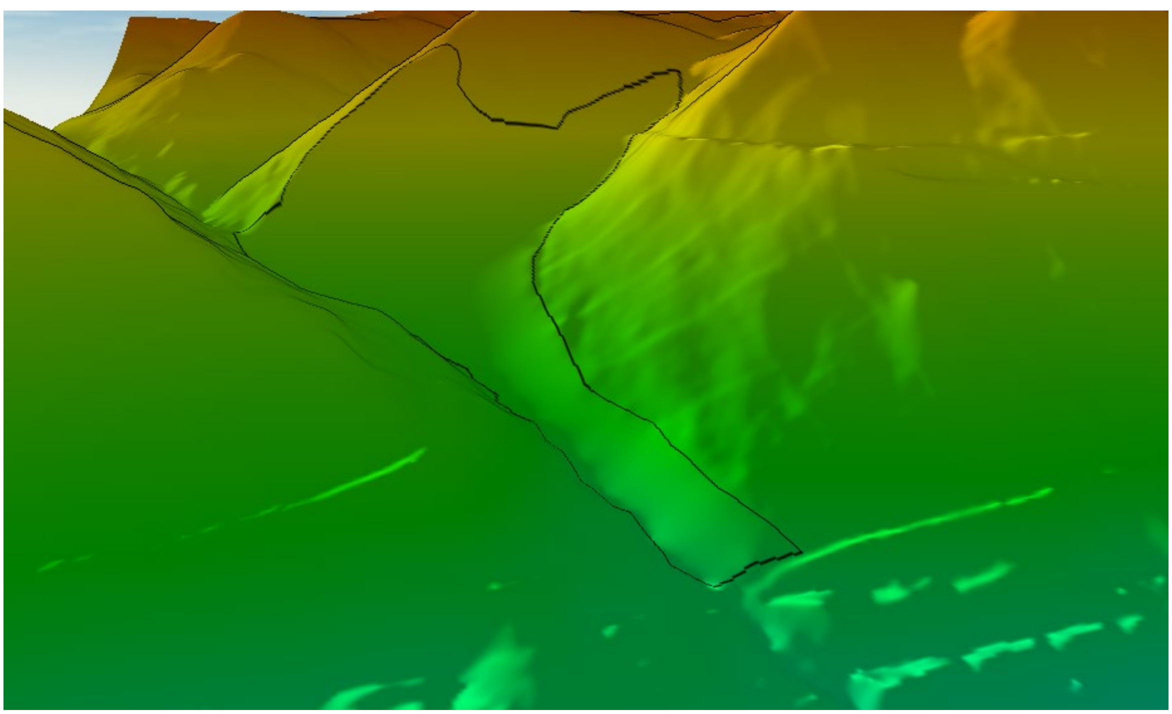
Rowid	VALUE	COUNT	AREA	VOLUME	
0	1	7783	83775.1797	1733751.9	
1	2	61	656.595909	-1060.47219	
2	3	1	10.763867	-5.155935	
3	4	1	10.763867	-3.22443	
4	5	1	10.763867	-0.617556	
5	6	7	75.347072	-80.778935	
6	7	193	2077.4264	-2171.08203	
7	8	4	43.055469	-6.61179	
8	9	1	10.763867	-0.896113	
9	10	1	10.763867	-0.336371	
10	11	1	10.763867	-1.902598	
11	12	1	10.763867	-0.714788	
12	13	11	118.402541	-50.926022	
13	14	2	21.527735	-2.853896	
14	15	2	21.527735	-1.508413	
15	16	15	161.45801	-59.400991	
16	17	4	43.055469	-42.861005	
17	18	6	64.583204	-26.418252	
18	19	3	32.291602	-7.894204	
19	20	2	21.527735	-3.269104	
20	21	6	64.583204	-19.09693	
21	22	1	10.763867	-3.458313	
22	23	11	118.402541	-16.781752	
23	24	1	10.763867	-0.402068	
24	25	5	53.819337	-6.120373	
25	26	4	43.055469	-5.100749	
26	27	3	32.291602	-12.832023	
27	28	1	10.763867	-1.789598	
28	29	4	43.055469	-5.752467	
				1730153.64	CF
				64079	CY

Unique ID: GEM_82622721

Current Surface:



Historical Surface:



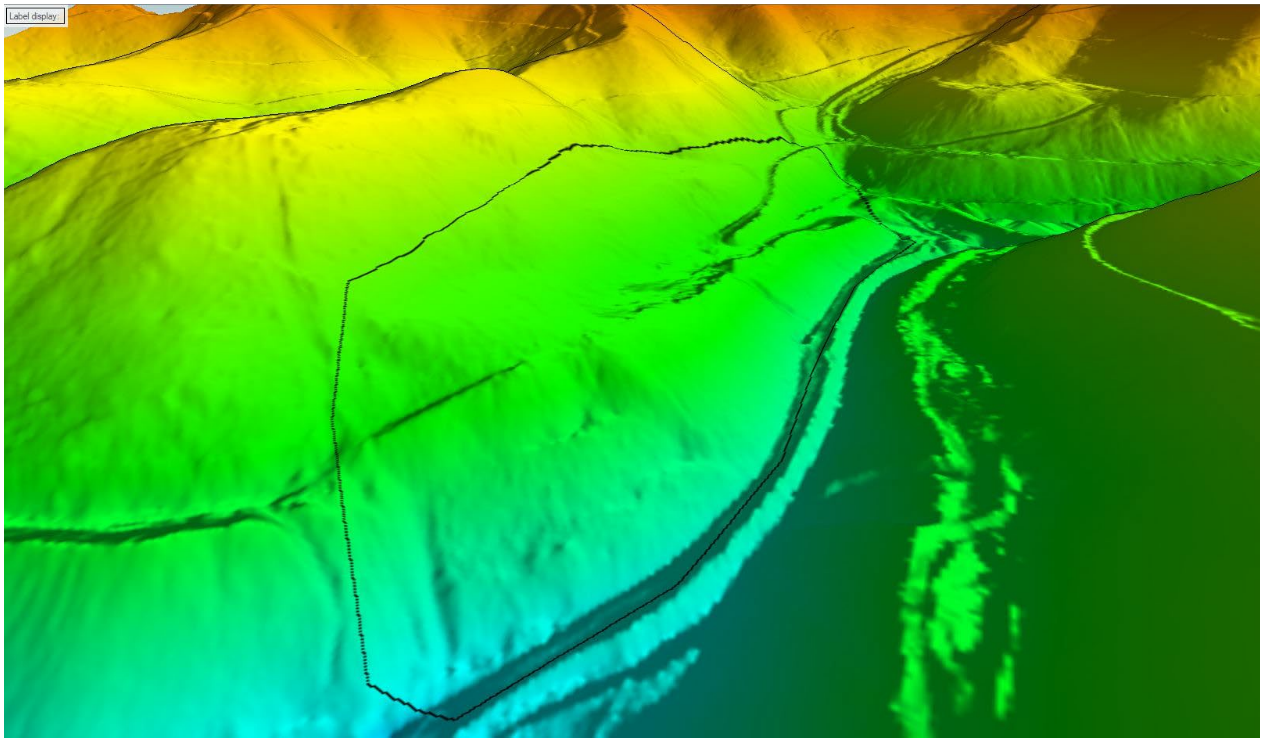
Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

Rowid	VALUE	COUNT	AREA	VOLUME
0	1	14551	232816	4212575.234
1	2	4	64	-73.041016
2	3	3	48	-48.320313
3	4	3	48	-20.011719
4	5	11	176	-176.384766
5	6	88	1408	-1707.820313
6	7	1	16	7.433594
7	8	1	16	-2.132813
8	9	1	16	-6.607422
9	10	2	32	-5.416016
10	11	1	16	-2.025391
11	12	1	16	-6.535156
12	13	33	528	-563.527344
13	14	1	16	-7.345703
14	15	2	32	-5.615234
15	16	1	16	-1.292969
16	17	60	960	-1055.419922
17	18	1	16	13.113281
18	19	46	736	-740.419922
19	20	1	16	-1.316406
20	21	3	48	-32.40625
21	22	4	64	-44.195313
22	23	362	5792	-9799.927734
23	24	2	32	-6.5
24	25	21	336	-491.638672
25	26	1	16	-0.367188
26	27	1	16	-3.003906
27	28	89	1424	-1845.15625
28	29	2	32	-18.410156
29	30	1	16	-0.783203
30	31	2	32	-6.179688
31	32	7	112	-34.724609
32	33	25	400	-484.765625
33	34	1	16	-5.138672
34	35	2	32	-10.623047
35	36	4	64	-18.615234
36	37	1	16	-22.667969
37	38	1	16	11.796875
38	39	4	64	30.882813
39	40	1	16	-0.082031
40	41	1	16	15.283203
41	42	1	16	0.308594
42	43	4	64	-25.582031
43	44	13	208	-180.919922
44	45	1	16	-1.835938
45	46	151	2416	-3984.873047

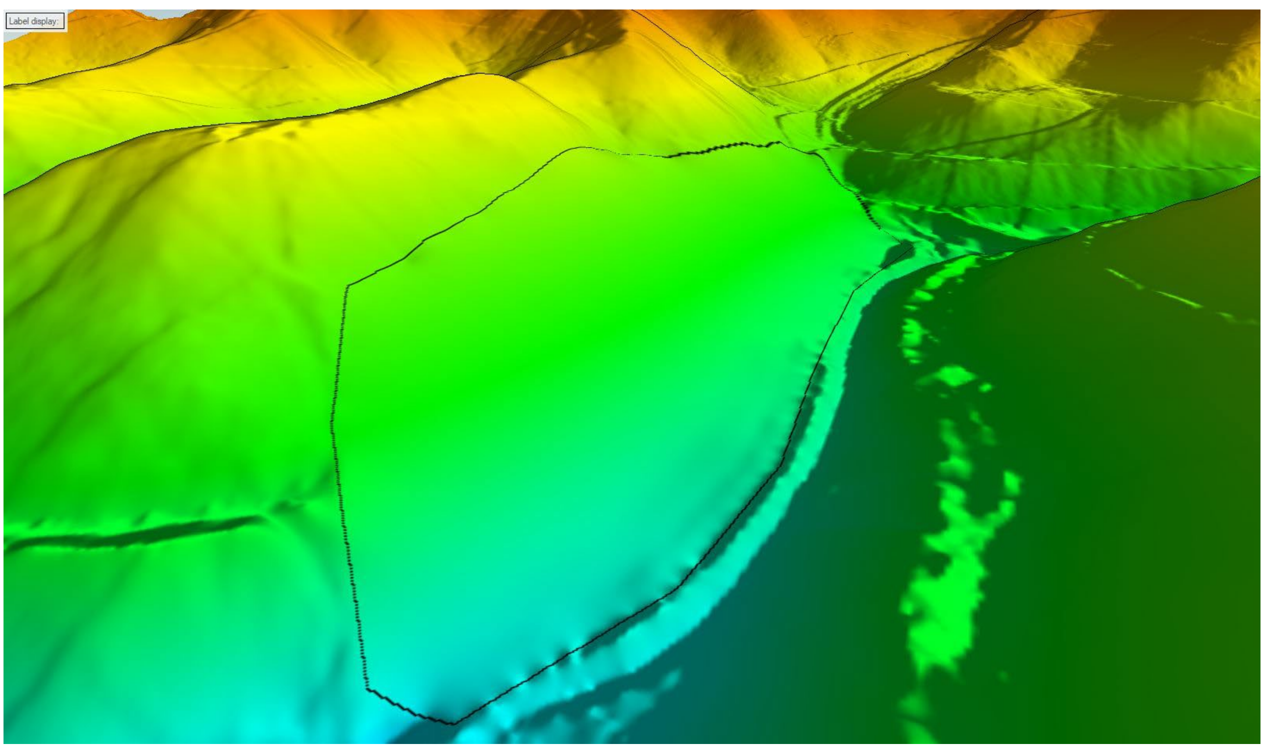
Rowid	VALUE	COUNT	AREA	VOLUME	
46	47	1	16	-0.267578	
47	48	45	720	-697.962891	
48	49	18	288	156.167969	
49	50	411	6576	-12777.63867	
50	51	4	64	37.839844	
51	52	13	208	144.810547	
52	53	9	144	101.570313	
53	54	1092	17472	50351.17383	
54	55	13	208	-103.429688	
55	56	2	32	15.328125	
56	57	1	16	-1.054688	
57	58	1	16	-1.0625	
58	59	6	96	-48.660156	
59	60	1	16	-0.101563	
60	61	1	16	-1.792969	
61	62	2	32	-5.882813	
62	63	7	112	-28.453125	
63	64	27	432	-393.796875	
64	65	2	32	-9.355469	
65	66	1	16	-7.277344	
66	67	2	32	-9.476563	
67	68	3	48	-18.949219	
68	69	2	32	-9.734375	
69	70	1	16	-1.015625	
				4227903.402	CF
				156589	CY

Unique ID: GEM_82322150

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create new grid using the trimmed contours.

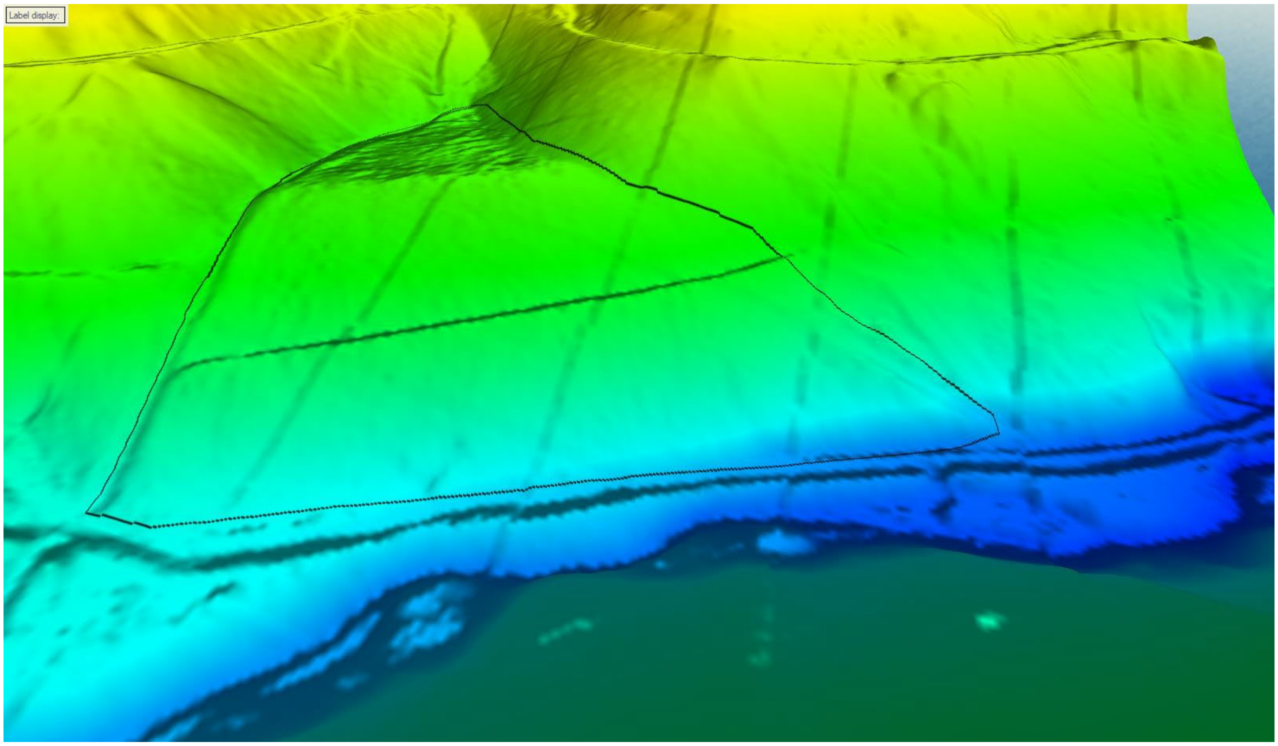
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	24725	266136.6205	3658959.582
2	2	7	75.347072	-47.783057
3	3	1029	11076.01952	-19134.59011
4	4	2	21.527735	7.807483
5	5	1	10.763867	2.340143
6	6	9	96.874806	54.8521
7	7	8	86.110939	-8.078156
8	8	1	10.763867	0.207604
9	9	1	10.763867	-1.729156
10	10	986	10613.17322	-24430.92792
11	11	36	387.499225	136.923961
12	12	1	10.763867	-0.203662
13	13	23	247.568949	-109.877642
14	14	2	21.527735	4.224345
15	15	19	204.51348	-256.911124
16	16	1	10.763867	-0.31929
17	17	9	96.874806	-21.95214
18	18	12	129.166408	-18.497769
19	19	7062	76014.4313	-308205.7705
20	20	1	10.763867	4.730215
21	21	22	236.805082	144.232144
22	22	1903	20483.63959	-35907.46001
23	23	1	10.763867	4.876063
24	24	11	118.402541	45.843668
25	25	1	10.763867	3.618615
26	26	20	215.277347	165.799297
27	27	8	86.110939	30.243156
28	28	5	53.819337	20.413506
29	29	1	10.763867	0.105116
30	30	213	2292.703748	1593.461007
31	31	3	32.291602	-4.3426
32	32	22	236.805082	87.305318
33	33	1	10.763867	0.097232
34	34	4	43.055469	4.347856
35	35	19	204.51348	117.012383
36	36	1	10.763867	1.199635
37	37	2	21.527735	2.125969
38	38	8	86.110939	14.508621
39	39	6	64.583204	8.670747
40	40	5	53.819337	-5.526468
41	41	3	32.291602	-8.857328
42	42	1	10.763867	0.411266
43	43	58	624.304307	-849.969732
44	44	20	215.277347	-135.416862
45	45	1	10.763867	-1.132624

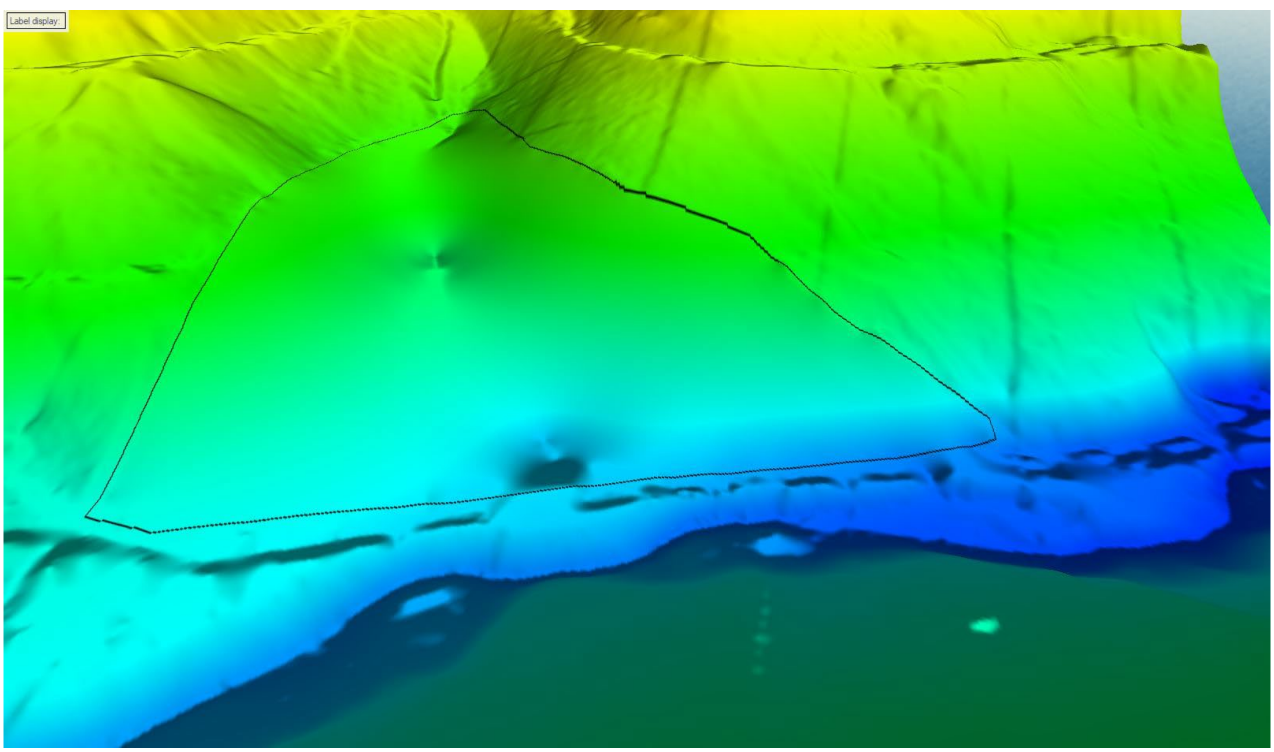
OBJECTID *	Value	Count	AREA	VOLUME	
46	46	5	53.819337	-8.513073	
47	47	9	96.874806	-23.972993	
48	48	4	43.055469	-9.293559	
49	49	1	10.763867	1.428262	
50	50	2	21.527735	2.860466	
				3272228.102	CF
				121193.6334	CY

Unique ID: GEM_82922152

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

4: Create dummy lines in the middle of the gob pile boundary to simulate valley in model.

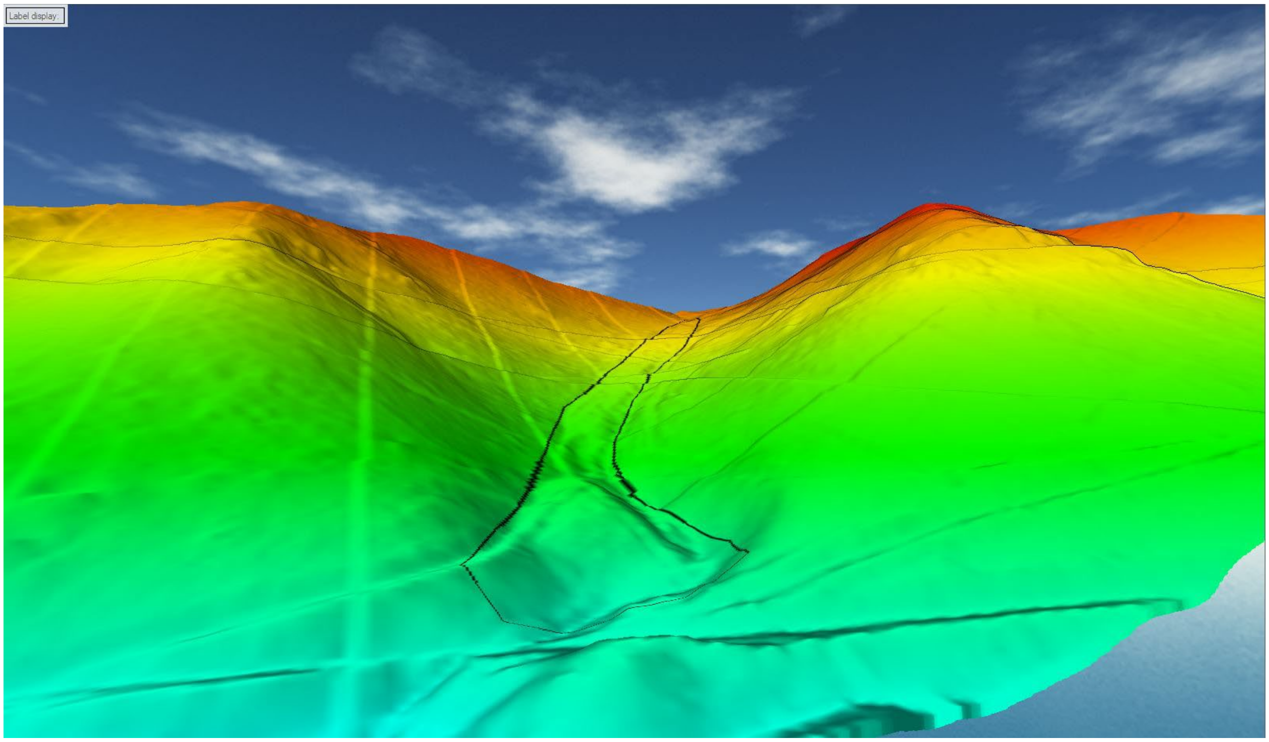
5: Create new grid using the trimmed contours (with the dummy lines on the inside).

6: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

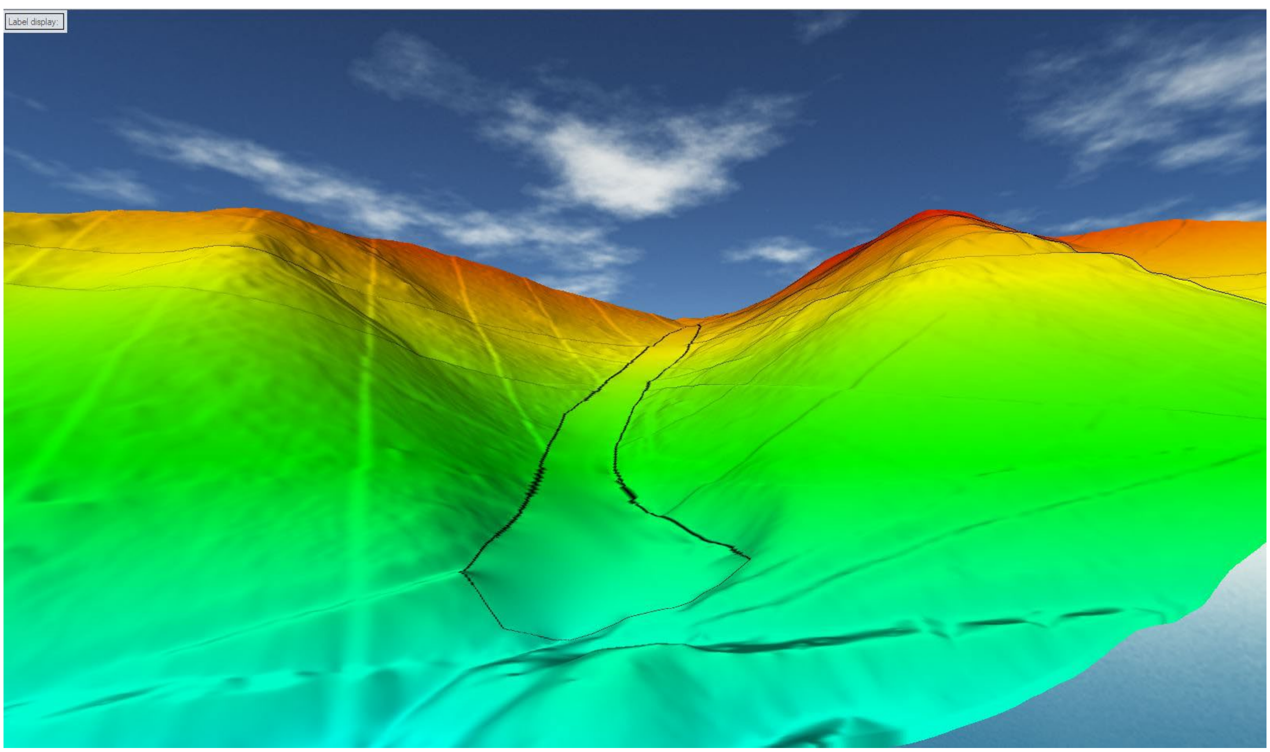
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	9558	102881.0442	1809432.283	
2	2	4	43.055469	-17.081332	
3	3	142	1528.469165	-891.661323	
4	4	1	10.763867	-0.047302	
5	5	1	10.763867	-0.530835	
6	6	3	32.291602	10.695542	
7	7	83	893.400991	-828.17658	
8	8	2	21.527735	3.663289	
9	9	1	10.763867	3.752637	
10	10	10	107.638674	-66.385942	
				1807646.511	CF
				66949.87077	CY

Unique ID: GEM_82922153

Current Surface:



Historical Surface:



Process Documentation:

1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.

2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.

3: Trim contours inside the gob pile boundary.

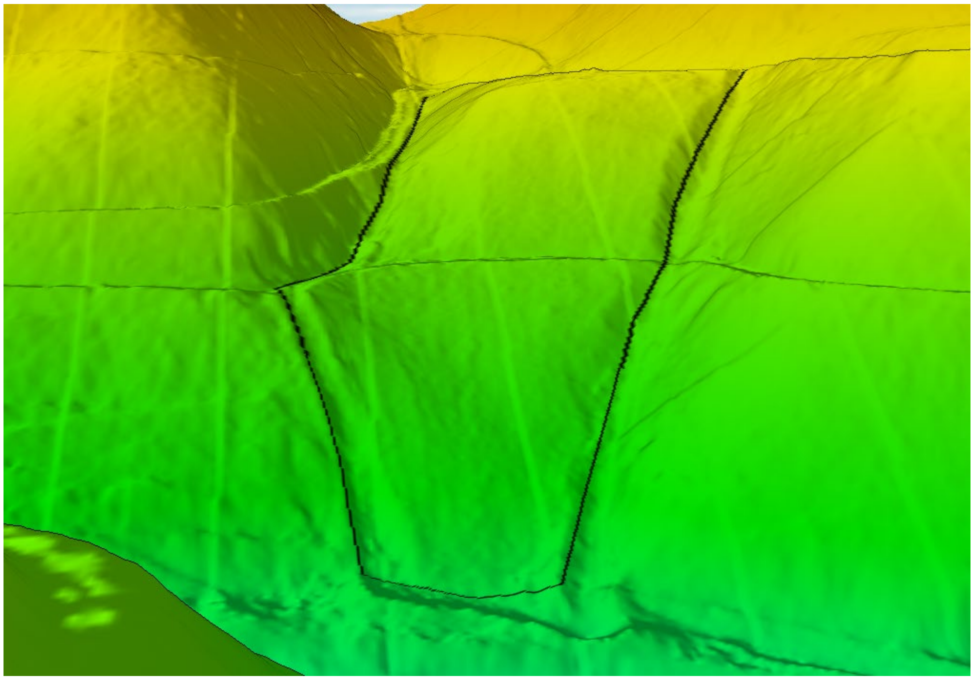
4: Create new grid using the trimmed contours.

5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

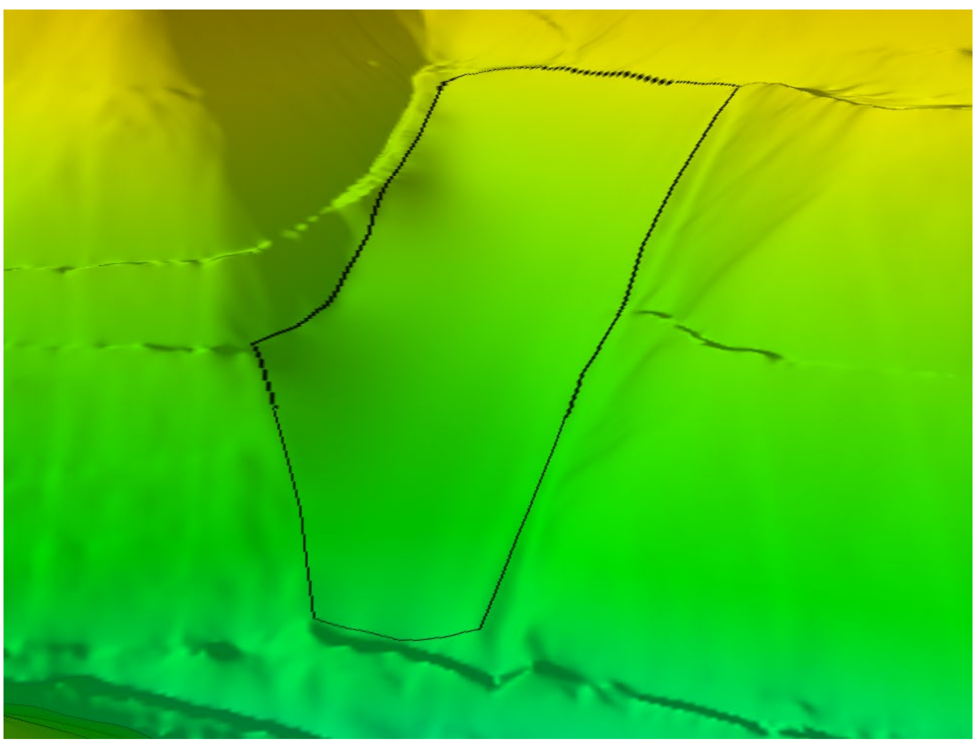
OBJECTID *	Value	Count	AREA	VOLUME	
1	1	3944	42452.69287	94757.26763	
2	2	20	215.277347	-144.418724	
3	3	1	10.763867	-1.826389	
4	4	14	150.694143	-59.135573	
5	5	1	10.763867	-5.426608	
6	6	1	10.763867	-1.161531	
7	7	30	322.916021	-225.058381	
8	8	6	64.583204	-13.8096	
9	9	4	43.055469	-9.321152	
10	10	5	53.819337	-13.82274	
11	11	19	204.51348	-70.243695	
12	12	9	96.874806	-12.419443	
13	13	9	96.874806	-53.724733	
14	14	10	107.638674	-22.902125	
15	15	1	10.763867	-0.370534	
16	16	44	473.610164	-217.119503	
17	17	1	10.763867	1.871063	
18	18	1	10.763867	0.409952	
19	19	148	1593.052369	-1526.695335	
20	20	1	10.763867	-3.043105	
21	21	1	10.763867	-2.953757	
22	22	56	602.776572	-256.382917	
23	23	2	21.527735	5.084981	
24	24	1	10.763867	1.944644	
25	25	1	10.763867	1.513669	
26	26	2	21.527735	9.308012	
27	27	2	21.527735	-1.363879	
28	28	24	258.332817	-92.79631	
29	29	2	21.527735	-4.194124	
30	30	52	559.721103	-400.544107	
31	31	509	5478.808487	-12613.42879	
32	32	1	10.763867	1.009113	
33	33	2	21.527735	3.505615	
34	34	1	10.763867	0.068325	
35	35	1	10.763867	0.927648	
36	36	2	21.527735	6.046792	
37	37	2	21.527735	10.193614	
38	38	1	10.763867	4.414867	
39	39	9	96.874806	20.381971	
40	40	1	10.763867	1.658203	
				79073.44304	CF
				2928.646039	CY

Unique ID: GEM_82922205

Current Surface:



Historical Surface:

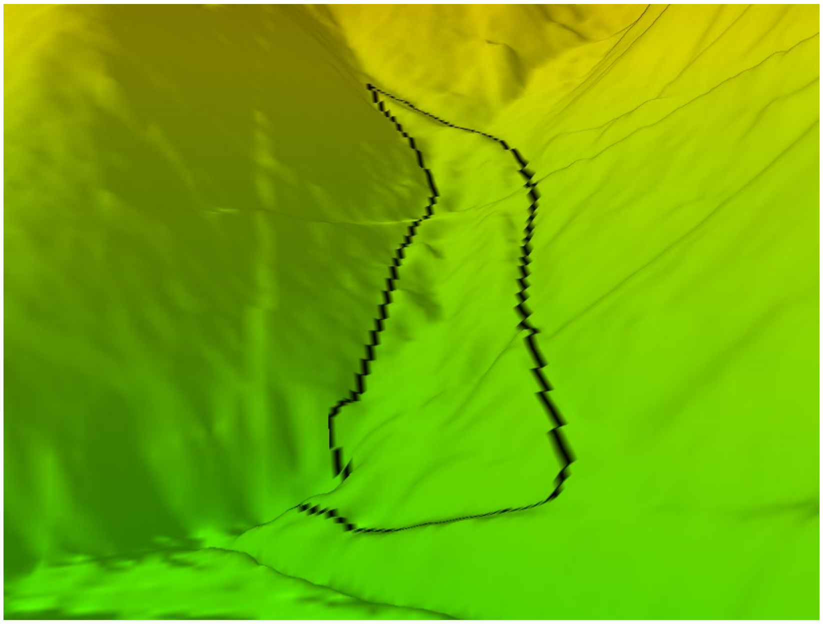


Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

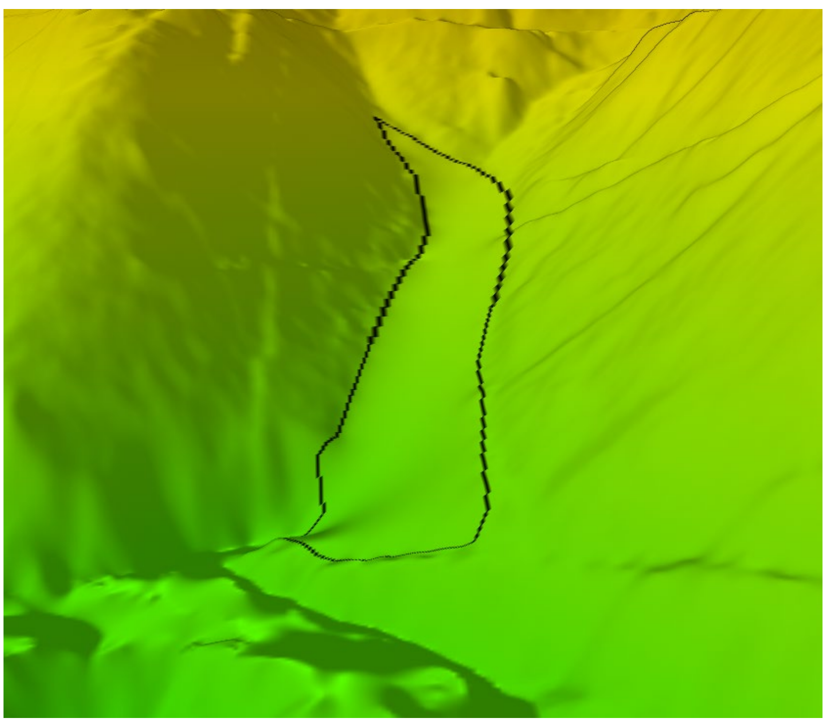
Rowid	VALUE	COUNT	AREA	VOLUME
0	1	15311	244976	4628622.883
1	2	3	48	-31.101563
2	3	1	16	-2.640625
3	4	19	304	-121.585938
4	5	16	256	-146.011719
5	6	14	224	-108.074219
6	7	4	64	-33.226563
7	8	3	48	-28.800781
8	9	3	48	-14.5625
9	10	3	48	-9.371094
10	11	1	16	-5.015625
11	12	3	48	-25.175781
12	13	1	16	-2.320313
13	14	113	1808	-1438.890625
14	15	1	16	3.695313
15	16	1	16	-0.882813
16	17	29	464	-235.539063
17	18	1	16	2.722656
18	19	3	48	-24.394531
19	20	1	16	-6.347656
20	21	2	32	-11.398438
21	22	2	32	-17.585938
22	23	3	48	-22.339844
23	24	1	16	-4.246094
24	25	1	16	-1.0625
25	26	336	5376	-11691.24609
26	27	1	16	-1.125
27	28	1	16	-8.882813
28	29	3	48	34.527344
29	30	1	16	3.351563
30	31	1	16	-9.71875
31	32	1	16	2.292969
32	33	2	32	4.25
33	34	40	640	-469.019531
34	35	1	16	-0.332031
35	36	1	16	-5.191406
36	37	1	16	-1.234375
37	38	3	48	-18.144531
38	39	1	16	-0.03125
39	40	5	80	-49.367188
				4614128.855 CF
				170893 CY

Unique ID: GEM_83022559

Current Surface:



Historical Surface:

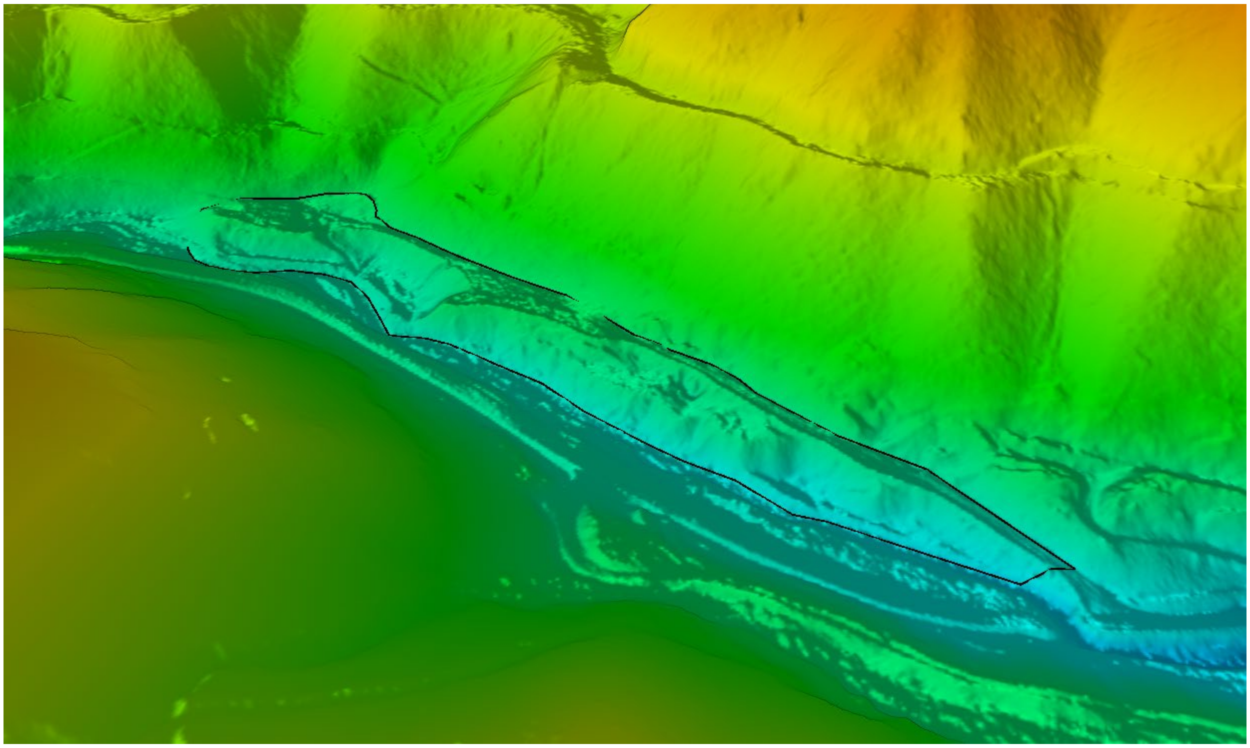


Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

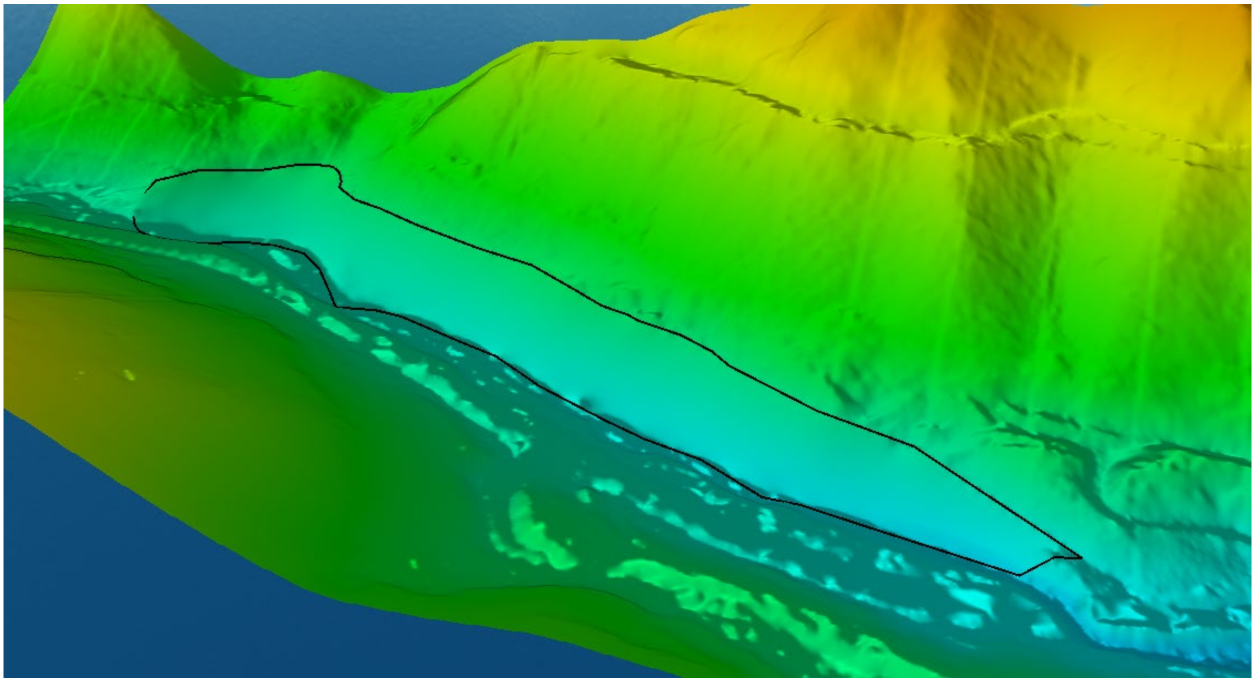
Rowid	VALUE	COUNT	AREA	VOLUME	
0	1	1235	13293.376	25409.284	
1	2	15	161.45801	-82.358302	
2	3	1	10.763867	3.245453	
3	4	23	247.56895	-181.45631	
4	5	1	10.763867	-0.541347	
5	6	4	43.055469	-6.551348	
6	7	152	1636.1078	-1423.0064	
7	8	1	10.763867	-5.510701	
8	9	1	10.763867	-3.066756	
9	10	5	53.819337	-22.260918	
10	11	1	10.763867	-3.600219	
11	12	1	10.763867	0.959183	
12	13	3	32.291602	-4.985121	
13	14	2	21.527735	-4.956214	
14	15	1	10.763867	-0.265418	
15	16	4	43.055469	-11.799259	
16	17	41	441.31856	-288.50633	
17	18	2	21.527735	-7.197811	
				23367.426	CF
				865	CY

Unique ID: GEM_83022610

Current Surface:



Historical Surface:



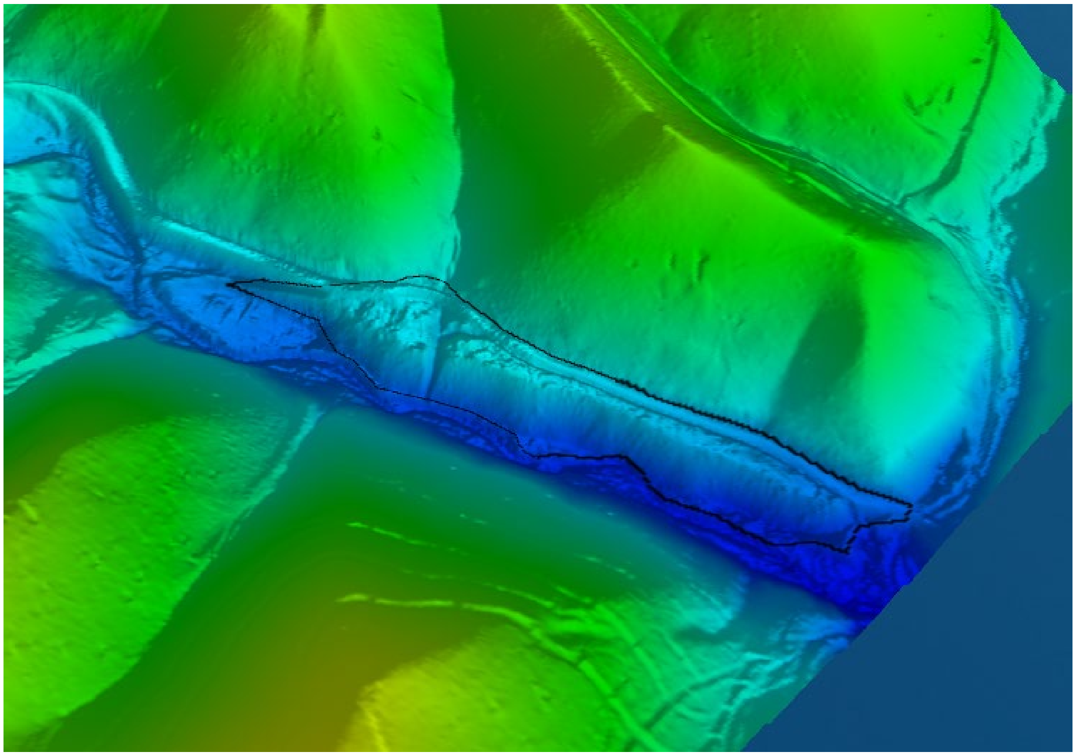
Process Documentation:
1: Define gob pile boundary by analyzing digital elevation model and comparing them with aerial imagery.
2: Take original digital elevation model (mosaic multiple ones if necessary) and generate contours.
3: Trim contours inside the gob pile boundary.
4: Create new grid using the trimmed contours.
5: Do a Cut Fill volumetric analysis of the pile comparing the original DEM and the new grid created using the gob pile as a mask.

OBJECTID *	Value	Count	AREA	VOLUME
1	1	22696	244296.7336	2636572.265
2	2	12	129.166408	-48.823704
3	3	3	32.291602	-1.445344
4	4	2	21.527735	-2.288899
5	5	9	96.874806	-57.430068
6	6	4	43.055469	-11.394563
7	7	2	21.527735	-0.843555
8	8	1	10.763867	-0.451998
9	9	3	32.291602	-1.673971
10	10	4	43.055469	1.702877
11	11	17	182.985745	-23.13338
12	12	2	21.527735	-0.504556
13	13	3	32.291602	-7.145253
14	14	1	10.763867	-0.323231
15	15	1	10.763867	-0.115627
16	16	1	10.763867	1.353367
17	17	15	161.45801	-54.928309
18	18	4	43.055469	-11.570632
19	19	1	10.763867	-2.302038
20	20	1	10.763867	-2.141736
21	21	1	10.763867	-0.338999
22	22	82	882.637124	-800.341892
23	23	5	53.819337	-6.803626
24	24	2	21.527735	-1.158903
25	25	11	118.402541	-58.770295
26	26	1	10.763867	-1.035392
27	27	1	10.763867	-0.793625
28	28	6	64.583204	-15.917174
29	29	1	10.763867	-0.215488
30	30	39	419.790827	-159.473948
31	31	2	21.527735	-3.707963
32	32	6	64.583204	-19.685579
33	33	10	107.638674	-37.73135
34	34	1	10.763867	-3.471452
35	35	6	64.583204	-8.256853
36	36	3	32.291602	-4.764378
37	37	1	10.763867	-0.378417
38	38	2	21.527735	-1.277158
39	39	1	10.763867	-2.596363
40	40	5	53.819337	-13.068533
41	41	2	21.527735	-5.497561
42	42	1	10.763867	-3.500359
43	43	2	21.527735	-1.621413
44	44	2	21.527735	-0.746323
45	45	16	172.221878	-71.076738
46	46	1	10.763867	-1.455855

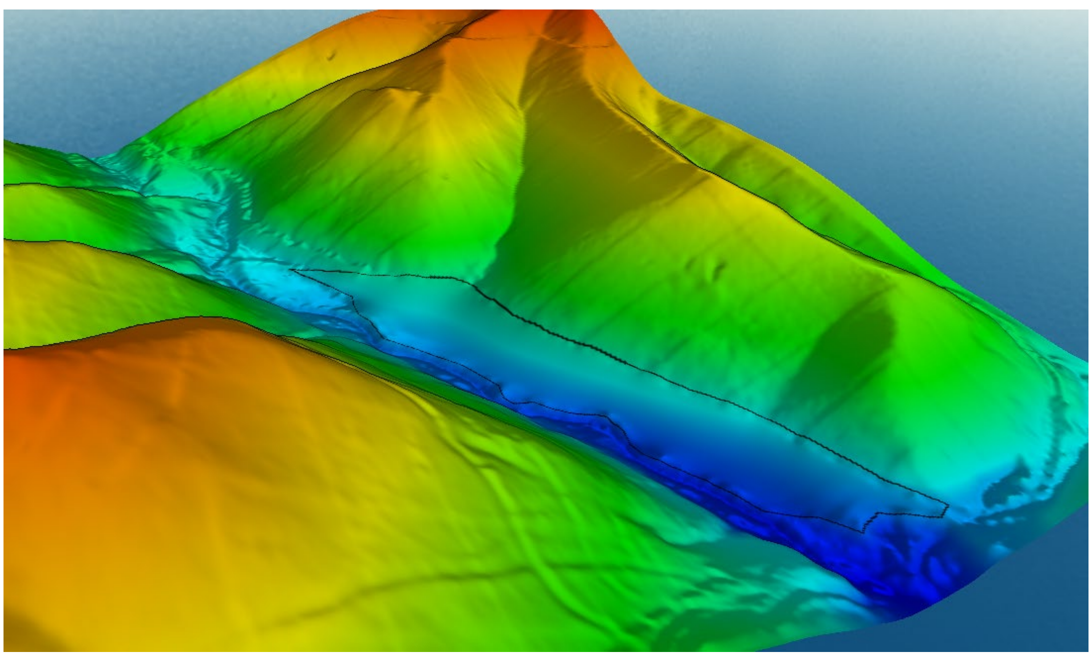
OBJECTID *	Value	Count	AREA	VOLUME
47	47	21	226.041215	-104.017431
48	48	1	10.763867	-0.373161
49	49	1	10.763867	-1.193065
50	50	2	21.527735	-1.434832
51	51	1	10.763867	-1.965667
52	52	1	10.763867	-0.967066
53	53	5	53.819337	-10.414357
54	54	1	10.763867	-1.122112
55	55	20	215.277347	-73.502288
56	56	1	10.763867	-2.864408
57	57	1	10.763867	-2.522781
58	58	3	32.291602	-2.012969
59	59	38	409.02696	-347.066397
60	60	1	10.763867	-0.622812
61	61	1	10.763867	-2.832873
62	62	1	10.763867	-0.402068
63	63	1	10.763867	-1.792226
64	64	8	86.110939	-22.061198
65	65	2	21.527735	-5.021912
66	66	1	10.763867	-1.613529
67	67	24	258.332817	-69.526279
68	68	1	10.763867	-0.77523
69	69	26	279.860551	-99.752354
70	70	5	53.819337	-15.449408
71	71	1	10.763867	-0.176069
				2634355.636 CF
				97569 CY

Unique ID: GEM_83022611

Current Surface:



Historical Surface:



Process Documentation:
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Rowid	VALUE	COUNT	AREA	VOLUME
0	1	534	5747.905171	-7425.7519
1	2	14965	161081.2751	1663933.347
2	3	1	10.763867	-0.023651
3	4	2	21.527735	-1.951214
4	5	651	7007.277652	-7309.09954
5	6	1	10.763867	0.946043
6	7	1	10.763867	4.583053
7	8	1	10.763867	9.83622
8	9	2	21.527735	-8.389562
9	10	1	10.763867	0.381045
10	11	1	10.763867	-5.560631
11	12	3	32.291602	-6.472511
12	13	24	258.332817	130.45145
13	14	65	699.651378	328.270362
14	15	1	10.763867	-0.44937
15	16	2	21.527735	7.619588
16	17	1	10.763867	0.635951
17	18	30	322.916021	-257.895272
18	19	38	409.02696	267.161238
19	20	2	21.527735	-11.356458
20	21	3	32.291602	-20.37803
21	22	265	2852.424851	-3383.46377
22	23	1	10.763867	0.730555
23	24	1	10.763867	4.123171
24	25	12	129.166408	42.056868
25	26	1	10.763867	-7.62353
26	27	372	4004.158658	-4249.63712
27	28	1	10.763867	0.608358
28	29	1	10.763867	0.084093
29	30	71	764.234583	348.440787
30	31	39	419.790827	-92.925077
31	32	4	43.055469	-7.622216
32	33	6	64.583204	11.359086
33	34	1	10.763867	2.889373
34	35	6	64.583204	-10.890006
35	36	6	64.583204	-8.676003
36	37	1	10.763867	-0.172127
37	38	66	710.415246	-293.126177
38	39	28	301.388286	-153.026402
39	40	3	32.291602	-9.105664
40	41	1	10.763867	0.596533
41	42	1	10.763867	-1.129996
42	43	1	10.763867	-0.986775
43	44	1	10.763867	-1.779086
44	45	7	75.347072	-9.941336
45	46	5	53.819337	-20.747249

Rowid	VALUE	COUNT	AREA	VOLUME	
46	47	2	21.527735	-8.114947	
47	48	1	10.763867	-1.312635	
48	49	1	10.763867	-1.997202	
49	50	1	10.763867	-0.295638	
50	51	16	172.221878	-90.310319	
51	52	6	64.583204	-8.154365	
52	53	1	10.763867	-2.074725	
53	54	3	32.291602	-5.67363	
54	55	3	32.291602	-4.475309	
				1641673.531	CF
				60802	CY

APPENDIX

5

VA ENERGY AUDIT OF MM&A WORK - RESULTS

From: Counts, Chris <chris.counts@energy.virginia.gov>
Sent: Friday, September 30, 2022 1:10 PM
To: Setareh Afrouz; Steve Keim; Jesse Whitt; Grace McCowan; Emily Williams
Subject: Volume comparison on audit of work
Attachments: VolumeComparison.xlsx

Good afternoon everyone,

After crunching the numbers on our end using the files Setareh provided we got similar numbers to what you guys had in the report. That is a pretty good indicator that we are on the right track with our methods. I have included a spreadsheet that shows the breakdown of each area. Feel free to reach out if you have any questions about the files we sent you Setareh. Sometimes when using different software packages the file conversions aren't smooth.

Thanks,

--
Chris Counts | Contractor GIS Specialist
VIRGINIA Energy
Virginia Department of Energy
chris.counts@energy.virginia.gov
(276) 523-8100 (Office) | (276) 608-4197 (Cell)