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TECHNICAL MEMORANDUM

TO: Mr. Charles "Hud" Heaton, P.E.
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FROM: Frank DeSantis, EA Deputy Project Manager

RE: **December 2023 Drone Flight Results for Open Detonation Grounds Former Seneca Army Depot, Romulus NY**
Contract Number: W912DY-22-D-0131
Task Order: W912DY22F0374

EA Engineering, Science, and Technology, Inc., PBC conducted three Unmanned Aerial System (UAS) flights at Former Seneca Army Depot, on 20 December 2023. The flights collected 2-Dimensional (2D) and 3-Dimensional (3D) data at the Open Detonation (OD) hills located within the OD Grounds (SEAD-006-R-01), covering an area of approximately 120 acres. The purpose of the UAS flights was to collect high-resolution imagery, create 3D models of current site conditions for estimation of the volume of soil comprising the OD hills. Due to the known sites hazard associated with unexploded ordnance (UXO) at the site, EA personnel conducted the drone flight while being escorted by a qualified UXO Technician in accordance with the anomaly avoidance procedures provided in EA's associated Accident Prevention Plan which is included as Appendix E of the Uniform Federal Policy Quality Assurance Project Plan[1].

1. PRE-FLIGHT

EA utilized Drone Deploy flight planning software to create the flight plans for the UAS flights**.** Prior to the flight, verification that there were no UAS flight restrictions over the Former Seneca Army Depot was conducted through coordination with the Federal Aviation Administration.

Once on-site, EA established and surveyed 10 temporary ground control points (GCPs) spatially distributed throughout the project area (**Table 1**). GCPs were established on existing roads or tire tracks, due to known UXO hazards at the site. The GCPs were surveyed using a Real-Time Kinematic (RTK) enabled Trimble R12 Global Navigational Satellite System (GNSS) Global Positioning System (GPS), marked with a temporary marking target. The GPS's accuracy was verified preplacement of the GCPs at the nearby National Geodetic Survey (NGS) monument in Romulus to ensure the quality of the data collected when establishing the GCPs (**Table 1**). The

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1 EA Engineering, Science, and Technology, Inc., PBC (EA). 2023 *Final, Uniform Federal Policy Quality Assurance Project Plan, Long-Term Monitoring/Land Use Controls Management Former Seneca Army Depot.* June

GCPs were used to spatially reference the collected drone imagery during subsequent data processing. The GCPs were removed at the end of each drone operation**.**

2. FLIGHTS

Three flights were conducted at the OD Grounds in the vicinity of the OD hills using a DJI Mavic Pro 2 quadcopter drone equipped with a 20 megapixel camera **(Table 2).** The first flight captured photos used to create the 2D model of the OD Grounds (**Figure 1**). The flight was conducted at an altitude of 300 feet (ft), captured 627 photos with an image resolution of 0.80 inches per pixel, and took approximately 35 minutes. The second flight captured photos used to create the 3D model of the OD Grounds (**Figure 2**). The flight was conducted at an altitude of 350 ft, captured 1,500 photos with an image resolution of 0.90 inches per pixel, and took approximately 75 minutes. The third flight captured photos used to create the 3D model of the OD hills. This flight was conducted at an altitude of 200 ft and covered primarily the 6-acre OD hills (**Figure 3**). The flight captured 450 photos with an image resolution of 0.50 inches per pixel and took approximately 25 minutes.

3. DATA PROCESSING

Post field data collection, the data was processed using PIX4D Mapper to generate high resolution 2D Orthomosiacs, Digital Surface Models (DSM), and 3D models using the process of Photogrammetry2.

PIX4D Mapper first plots all the photo locations based on the coordinates collected by the drone's internal GPS at the time the image was captured. Keypoints are then computed on all the images. These keypoints allow the software to be able to find matches between images. **Figure 4** depicts this process with the green circles representing the photo location and the blue lines representing the photos field of view. Once this is completed the software is then able to build Point Clouds, 3D meshes, DSM, and Orthomosiacs.

The 2D flight data was used to create a high resolution Orthomosiac with a horizontal accuracy of 1 inch. The 3D flights data was used to create DSMs and 3D meshes with a horizontal accuracy of 0.72 inches and vertical accuracy of 1 inch**.**

4. DELIVERABLES

2D
High resolution 2D Orthomosiac TIFF – Current site conditions were captured and can be used in future analysis of the OD Grounds. Using the high resolution 2D Orthomosiac, 31 ponded

2 Photogrammetry is the process of measuring from images. The captured overlapping images are processed by triangulating all the photographed points to create accurate 2D and 3D maps/models. Its key purpose is digitizing reality for surveying and mapping.

water features were identified, cataloged, and their area calculated (**Table 3 and Figure 5)**. The elevation of these ponds was also calculated using the collected 3D data.

3D
3D Textured Mesh - Current site conditions were also captured in 3D and can be used to facilitate future analysis of the OD Grounds.

Digital Surface Models - Using the DSM, PIX4D Mapper calculated the approximate volume of the OD hills. The Triangulation Method of interpolation was used to estimate volume. This method connects all the vertices around the hills and triangulates the volume above the surface**.** Triangulation is the recommended option when boundaries of stockpiles are visible and the area around the stockpile is relatively flat.

The DSM was used to determine the elevation of OD hills and the surrounding area **(Figure 6).** The max elevation of the OD hills is 651 ft. The lowest point to the north of the OD hills is 625 ft. The lowest point to the south of the OD hills is 624 ft. The lowest point to the west of the OD hills is 630 ft. The lowest point to the East of the OD hills is 615.

A slope analysis of the entire site was also performed using the DSM to identify areas where the slope was greater than 20° **(Figure 7)** and 30° **(Figure 8).** Areas in red represent slopes greater than 30°; however, potential errors were observed in areas where tall trees are located. The software identifies the tree areas as slopes greater than 30° due to the sudden elevation change from the top of the tree to the ground.

5. FUTURE FLIGHTS

UAS flights are planned to occur in the Spring of 2024 following leaf out. This effort will include UAS data collection of the entirety of the OD Grounds and surrounding areas. The data collected during these flights will capture current site conditions and be used to analyze vegetation density to inform potential clearing requirements.

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2 Drone Deploy 3D Flight Path - Open Detonation Grounds

3 Drone Deploy 3D Flight Path - Open Detonation Hills

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Table 1. GCP and Instrument Verification			
Instrument Verification			
ID	**Northing**	**Easting**	**Vertical**
Instrument Verification	990367.445	756375.109	749.455
NGS Benchmark - Romulus	990367.530	756375.110	749.374
Precisons	0.085	0.001	-0.081
Coordinates System: NAD 1983 New York State Plane - Central - US Feet			
Ground Control Points			
ID	**Northing**	**Easting**	**Vertical**
GCP-0	1012856.806	738230.036	641.45
GCP-1	1013082.605	738243.242	627.157
GCP-2	1011719.279	738775.639	629.682
GCP-3	1012098.049	738234.174	635.172
GCP-4	1012873.881	739156.626	616.78
GCP-5	1013630.932	738726.201	613.419
GCP-6	1012255.571	739887.723	620.588
GCP-7	1012612.806	738638.955	621.979
GCP-8	1012453.982	738275.72	633.221
GCP-9	1011602.799	738298.355	636.075
GCP-10	1012856.632	738229.756	641.568
Coordinates System: NAD 1983 New York State Plane - Central - US Feet			

Table 2. 20-megapixel Camera Specs	
Sensor	1” CMOS
	Effective Pixels: 20 million
Lens	FOV: about 77°
	35 mm Format Equivalent: 28 mm
	Aperture: f/2.8–f/11
	Shooting Range: 1 m to ∞
Still Image Size	5472×3648

Figure 3. Ponded Features				
Pond ID	**Northing**	**Easting**	**Elevation**	**Area (sqft)**
1	1011561.379	738784.902	628.057	70559.380
2	1011371.102	738364.146	631.009	5911.042
3	1011706.246	738456.004	630.650	6838.317
4	1012121.221	739080.402	619.868	29396.118
5	1012129.526	739347.285	619.571	32708.572
6	1011923.046	739341.064	618.935	25786.933
7	1011954.927	739396.988	618.500	263.052
8	1012222.700	739584.222	620.012	1428.239
9	1012168.232	739645.768	619.820	2995.695
10	1012074.747	738940.347	620.476	2894.653
11	1011871.865	738956.892	623.155	1294.253
12	1011896.663	738993.907	622.307	392.974
13	1012135.160	738831.981	623.425	4274.635
14	1012056.556	738813.029	623.264	502.218
15	1011941.932	738583.420	624.221	13352.074
16	1011659.179	737944.424	633.995	4147.664
17	1011626.245	737704.732	634.253	148.821
18	1011615.226	737742.236	645.205	538.950
19	1011449.998	738172.046	634.514	798.468
20	1012125.431	737887.351	633.430	6091.160
21	1013095.129	737902.457	625.706	7817.656
22	1011867.067	740129.014	618.946	4366.600
23	1011873.947	739945.978	619.533	2558.988
24	1011972.218	739725.178	617.928	4063.298
25	1011897.421	738017.123	634.092	5466.918
26	1011881.128	737907.641	633.937	5414.800
27	1011559.837	738069.484	634.751	2193.596
28	1011436.618	738102.925	635.608	1269.724
29	1011582.234	738213.799	634.484	702.515
30	1012040.065	738449.021	626.272	475.847
31	1013142.958	737396.711	622.502	922.219
Coordinates System: NAD 1983 New York State Plane - Central - US Feet				
Northing. Easting, and Elevation were collected at the center of the pond.				

Table 4. Open Detonation Hills Approximate Volume Calculation			
	Cut Volume (cubic feet)	Cut Volume Error (cubic feet)	Total Volume (cubic feet)
Volume (cubic feet)	979,571.00	11,398.70	968,160.00
Volume (cubic yards)			35,857.78

Figures

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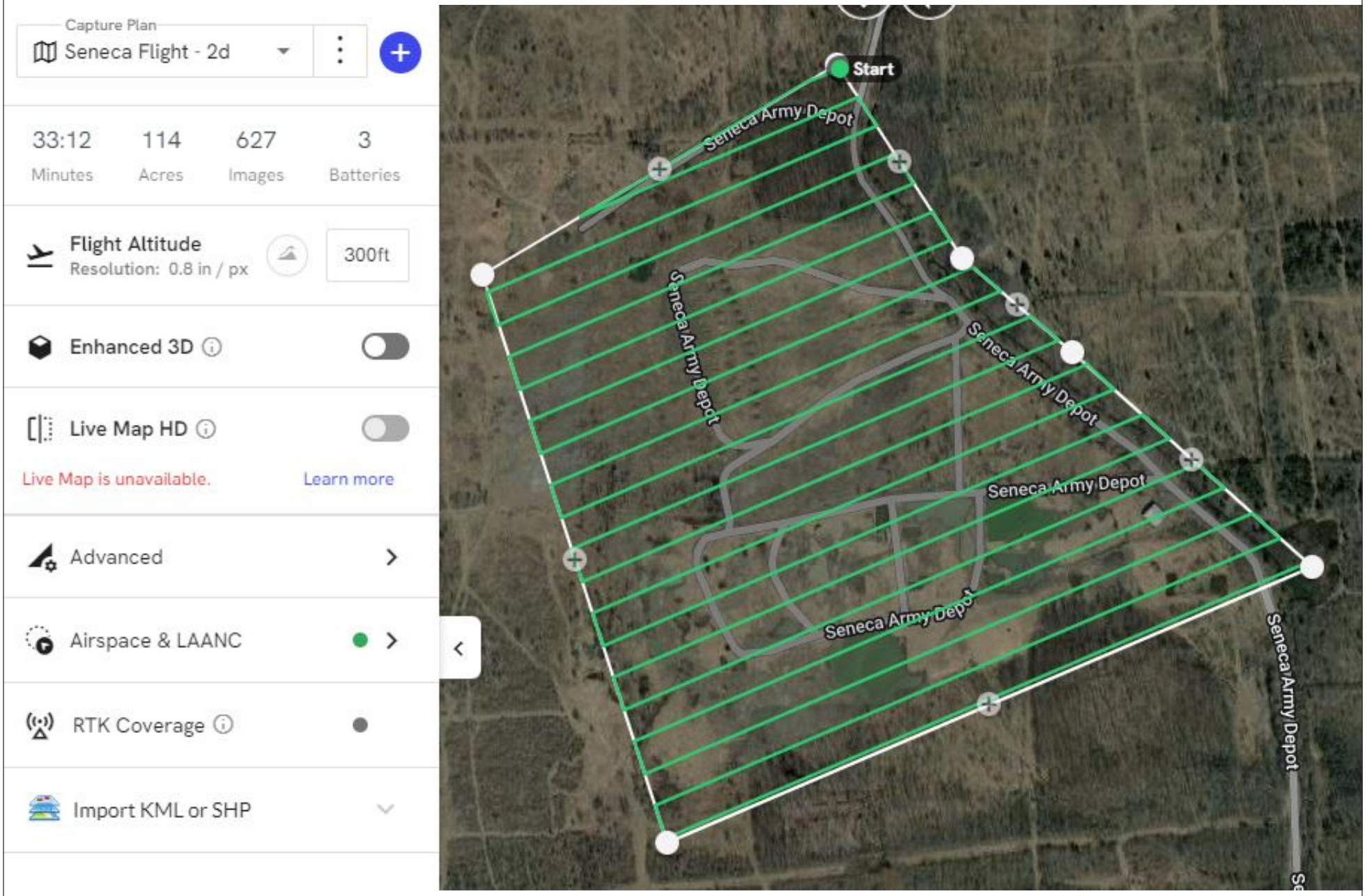

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Figure 1. Drone Deploy 2D Flight Path - Open Detonation Grounds

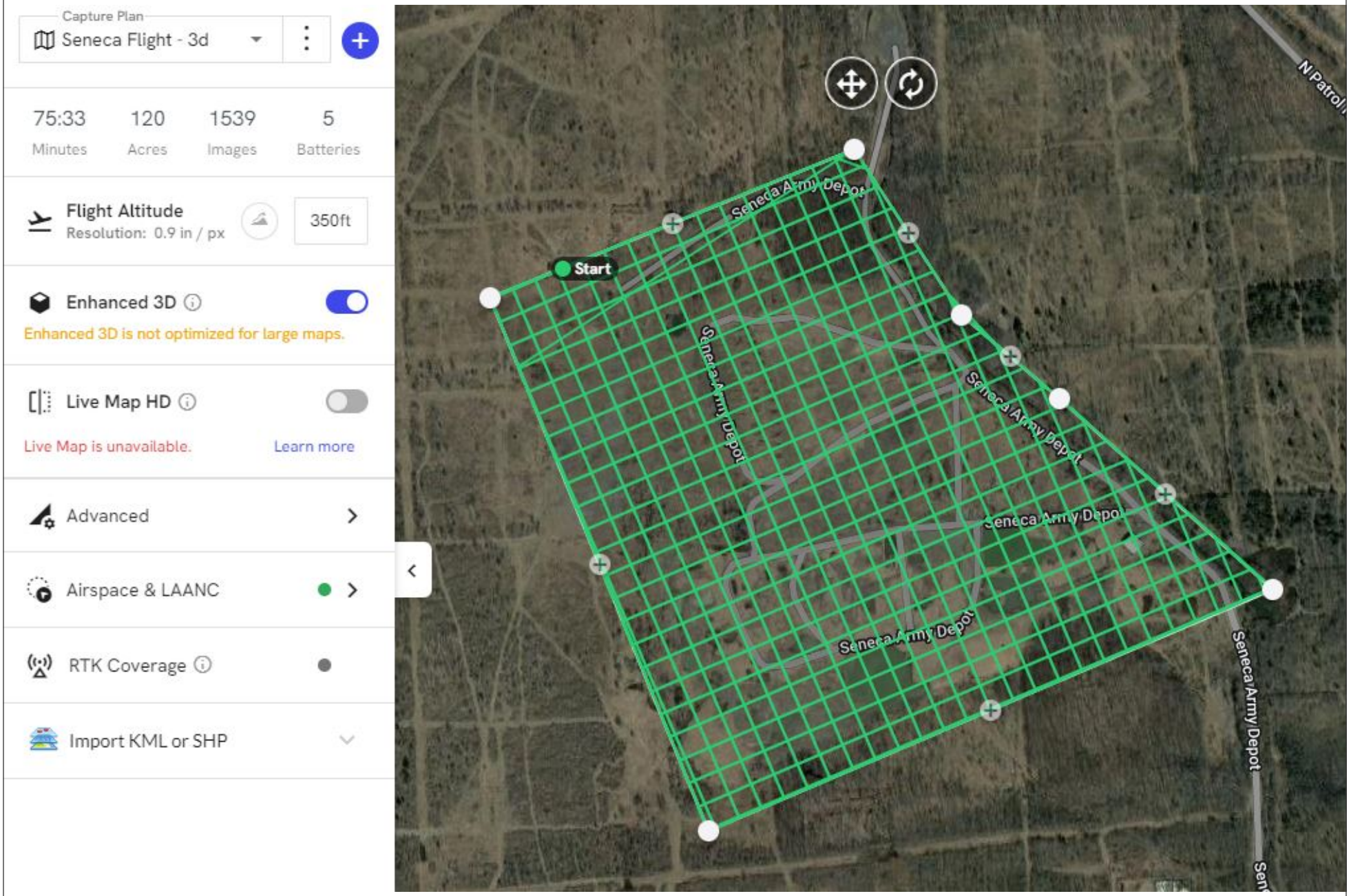

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Figure 2. Drone Deploy 3D Flight Path - Open Detonation Grounds

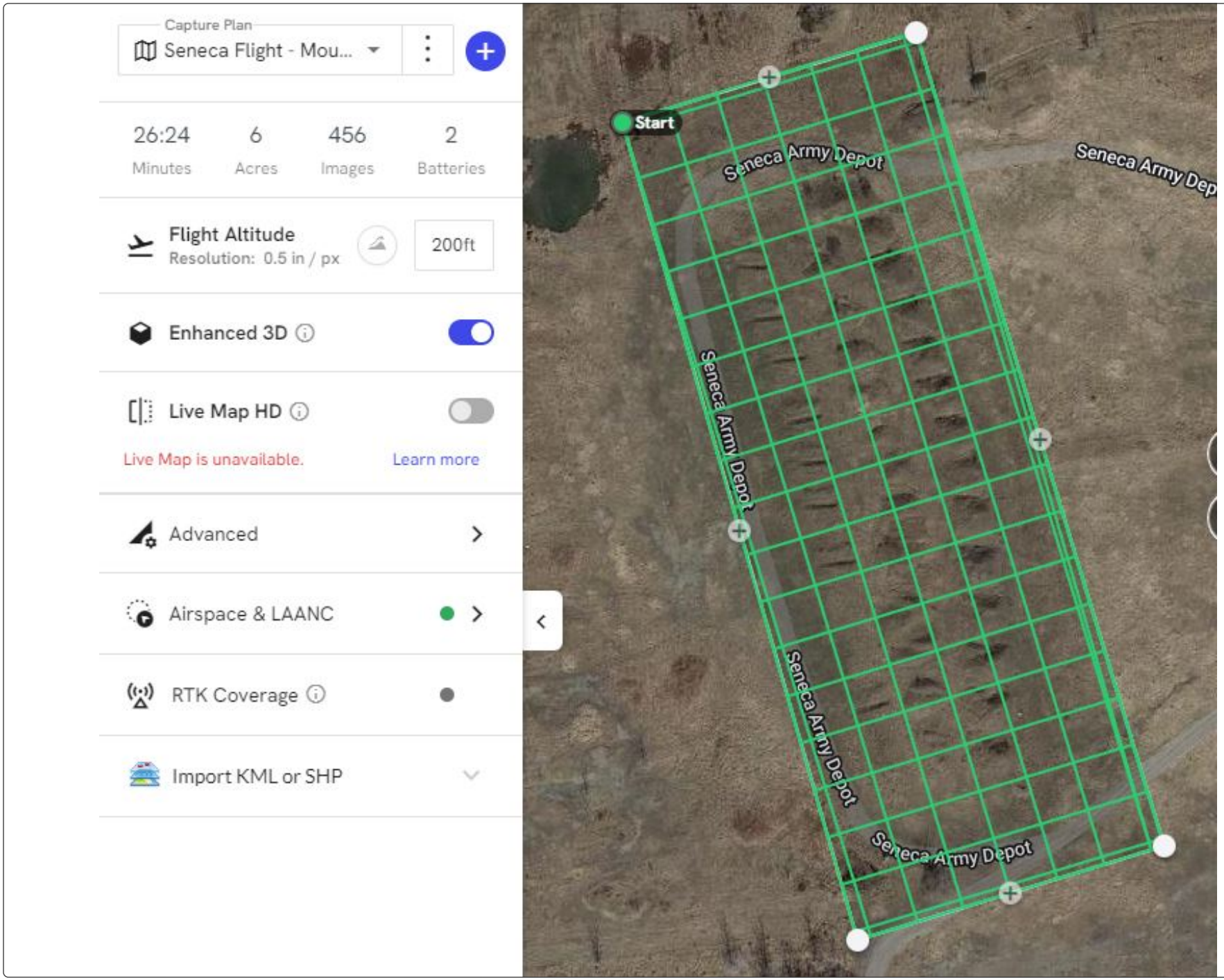

Figure 3. Drone Deploy 3D Flight Path - Open Detonation Hills

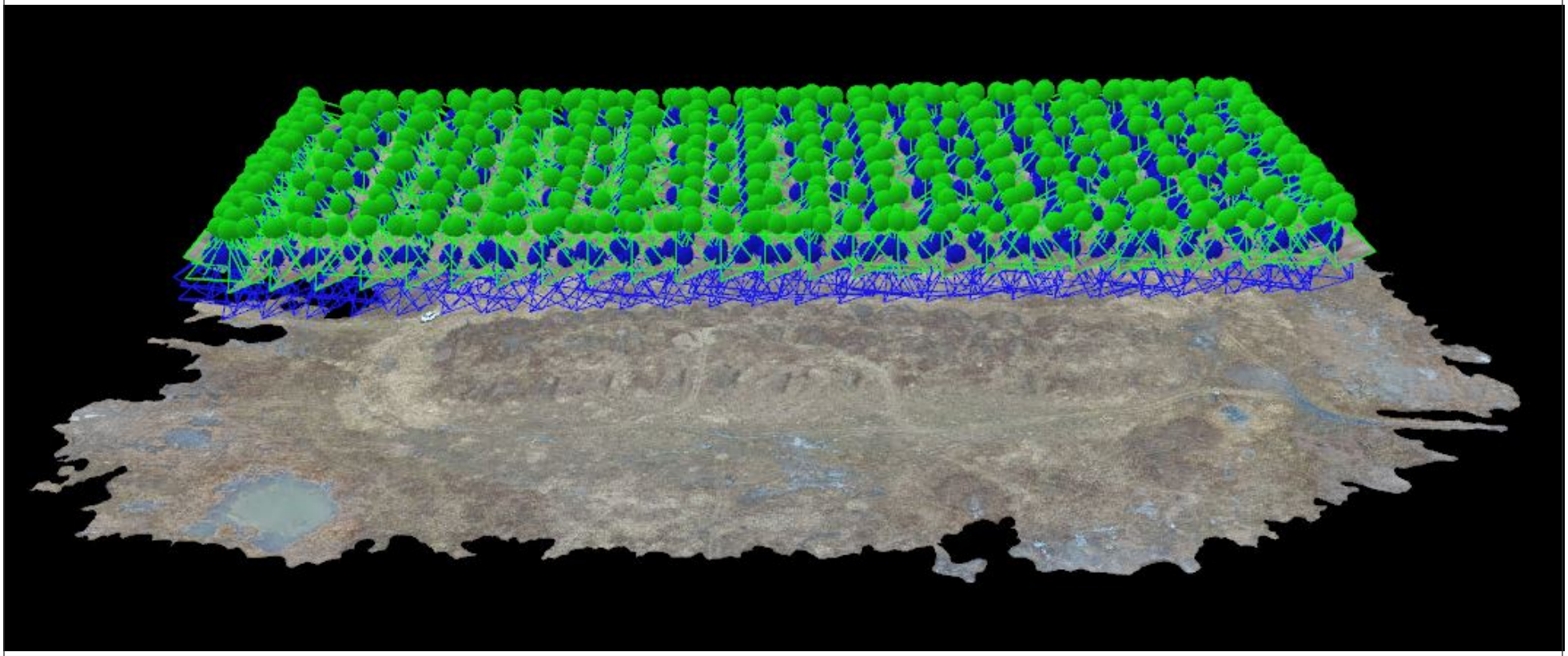

Figure 4. PIX4D - Drone Data Processing

Legend

Pond

Number	Area (sft)
1	70,559
2	5,911
3	6,838
4	29,396
5	32,709
6	25,787
7	263
8	1,428
9	2,996
10	2,895
11	1,294
12	393
13	4,275
14	502
15	13,352
16	4,148
17	149
18	539
19	798
20	6,091
21	7,818
22	4,367
23	2,559
24	4,063
25	5,467
26	5,415
27	2,194
28	1,270
29	703
30	476
31	922
Total (sft)	**245,577**
Total (acres)	**5.64**

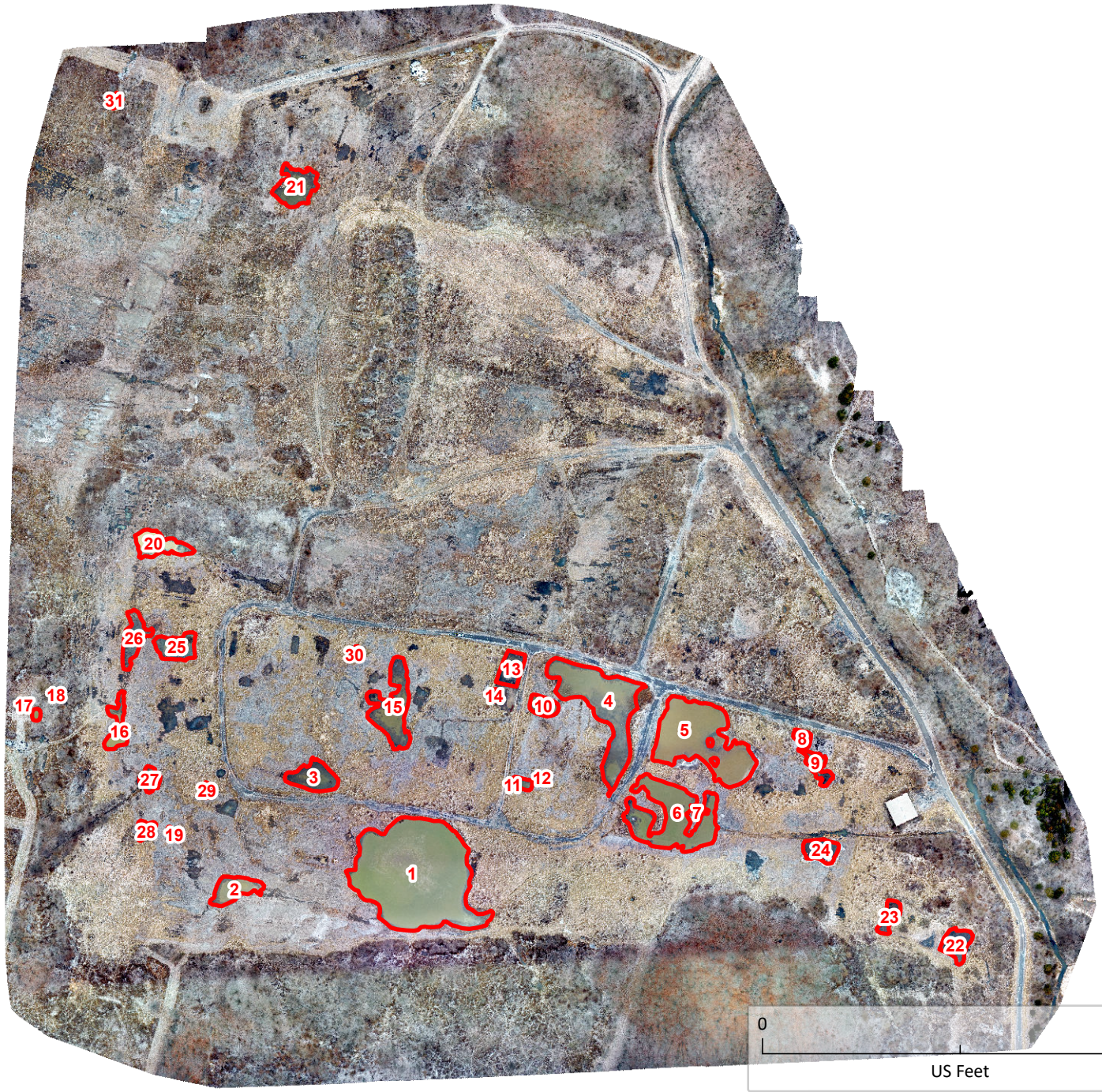

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Figure 5. Pond Locations

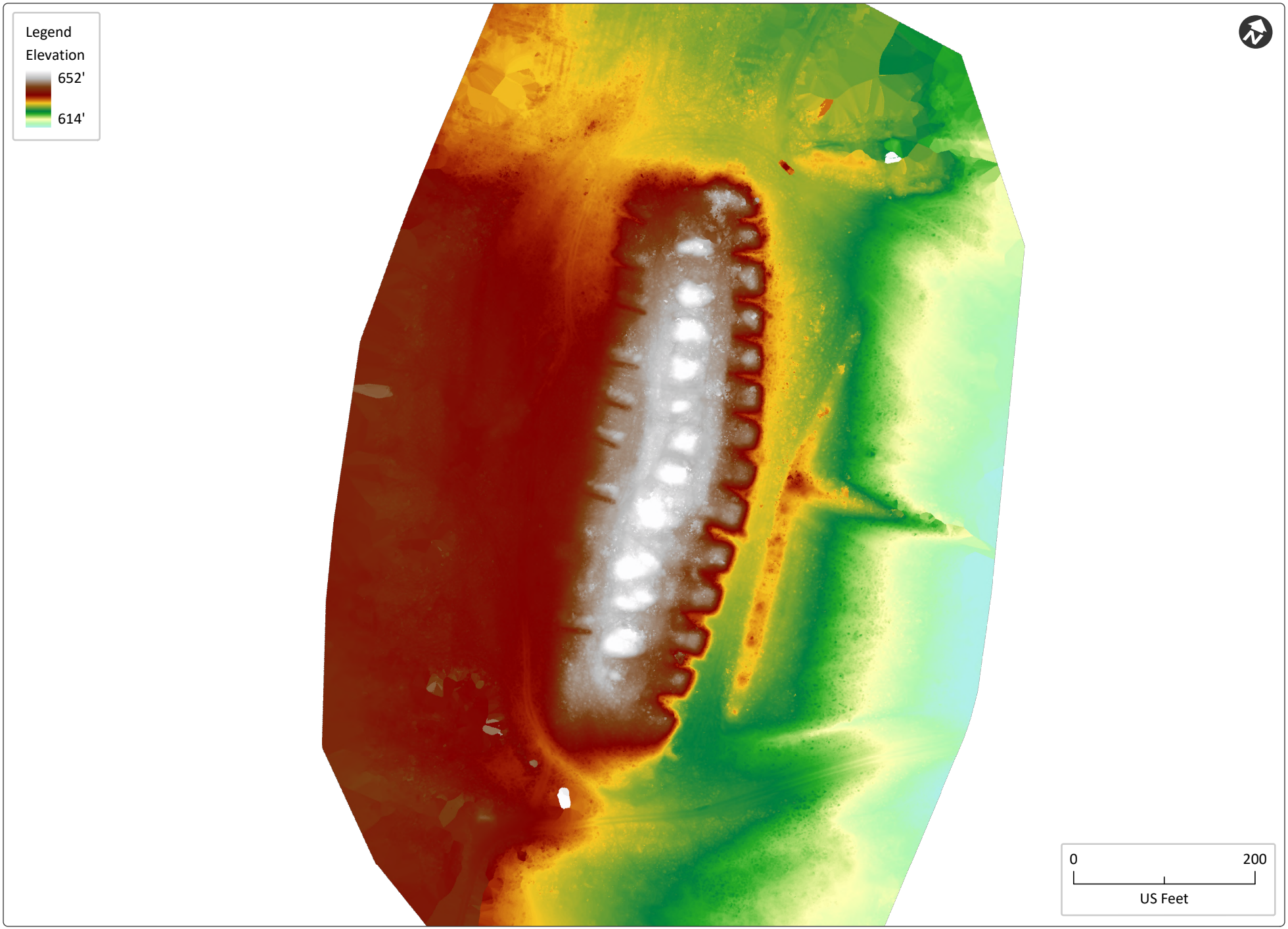

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Figure 6. Digital Surface Model- Open Detonation Hills

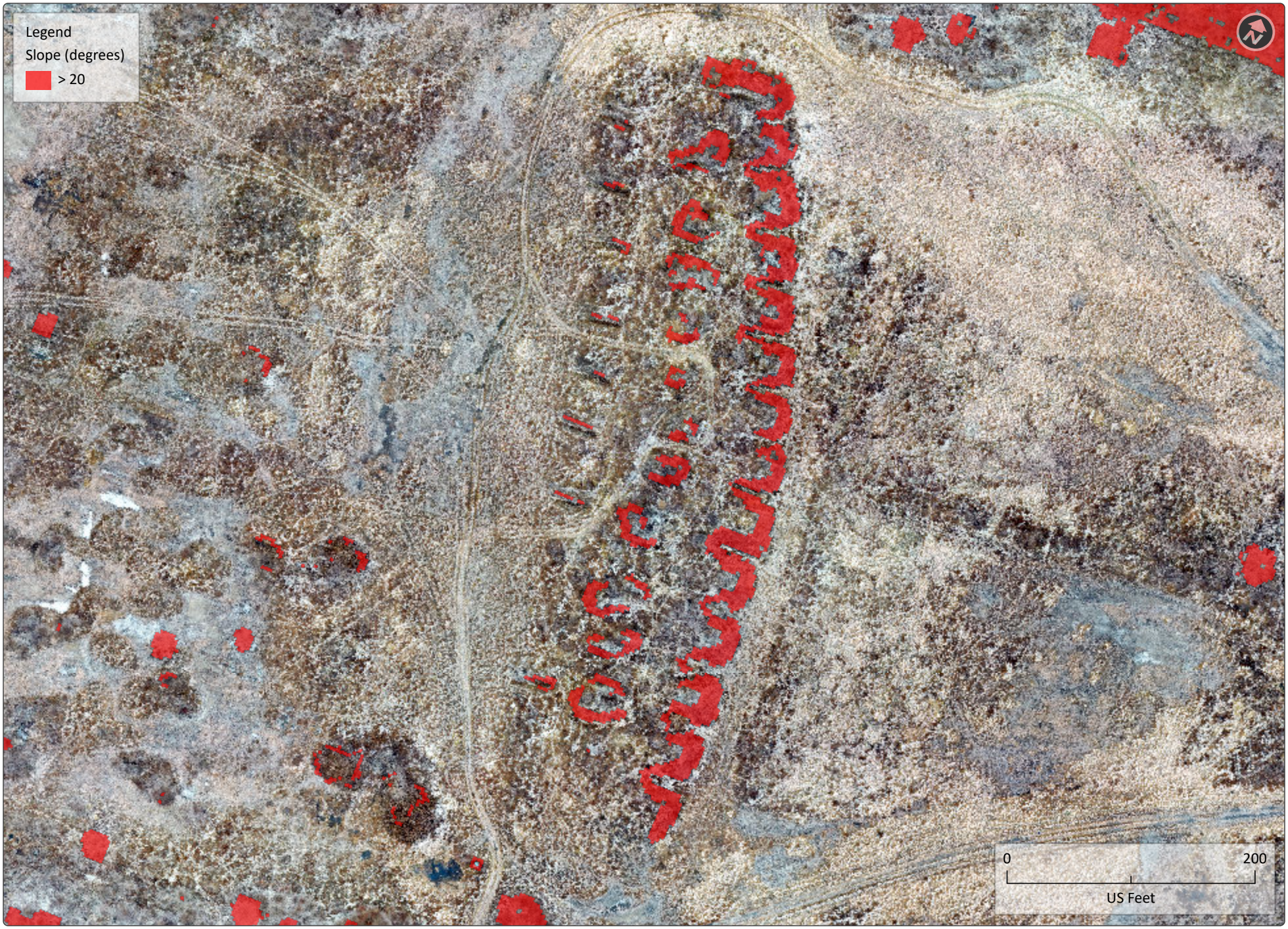

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Figure 7. Slope Analysis - >20° - Open Detonation Hills

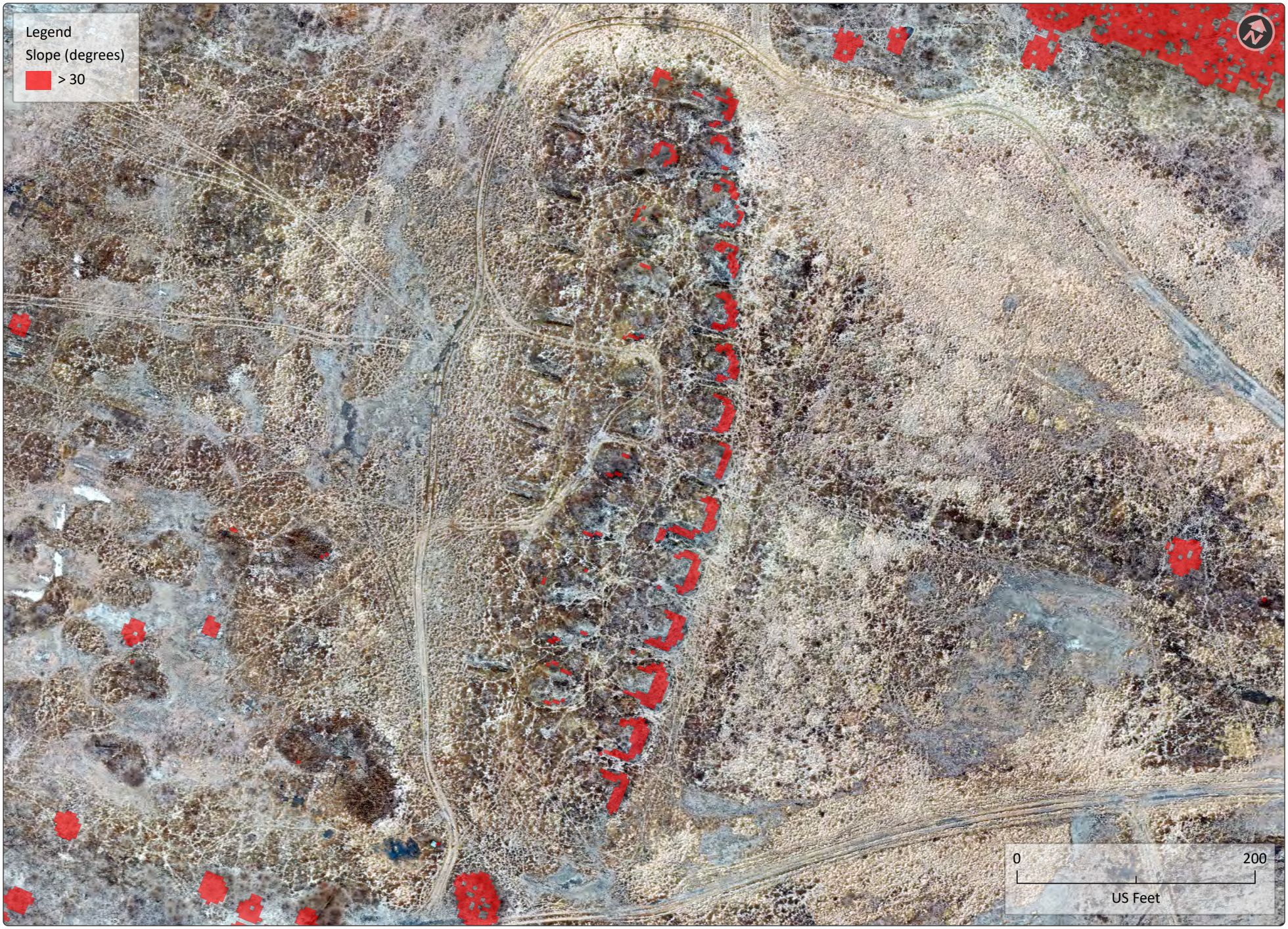

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Figure 8. Slope Analysis - >30° - Open Detonation Hills