TECHNICAL MEMORANDUM

OWENS LAKE
SCIENCE, TECHNOLOGY & REGULATORY PROJECT TEAM

# KEELER DUNES SAND MASS ESTIMATION


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Sand mass analysis of the Keeler Dune complex was conducted to determine volumes within the existing younger dune field and the preserved older dunes east of Keeler. This technical memorandum documents the methodology and assumptions used to derive sand mass estimates and summarizes the potential mass of sand eroded from the older Keeler Dune shoreline stand that has been ablated.

## Methodology

LiDAR data collected in 2012 were used as the basis for estimating dune extent, height, and volume. Volume estimates were then converted to mass using literature values for sand dune bulk density. The primary sand dune extent was delineated manually using July 2012 satellite imagery, 2012 LiDAR bare earth digital elevation model (DEM) data, and DEM derivatives (slope, aspect, and relief shade). Polygons were drawn around each major dune or dune complex, omitting the Keeler Dune sand sheet and smaller, dispersed coppice dunes (Figure 1).

Additional non-dune, bare ground areas within the polygon delineations were visually identified and removed from the sand dune polygons. This was done to bolster the natural, non-dune surface interpolation by providing some guidance and data points within the larger sand dune complex for interpolation purposes. The resultant sand dune polygons were used to remove LiDAR elevation data in the sand dune area (Figure 2).

The natural, non-dune surface was estimated using a global polynomial interpolation with a $6^{th}$ order polynomial fit (Figure 3). The natural surface was then differenced from the bare earth digital elevation model to approximate sand dune height. Volume and mass of each sand dune was then calculated. Mass was derived from volume using an average bulk density of 1650 kg / $m^3$ or 103 lbs/$ft^3$ considered representative of Keeler Dune sand (Pye et al., 1974).

**Figure 1. Sample Selection Data**

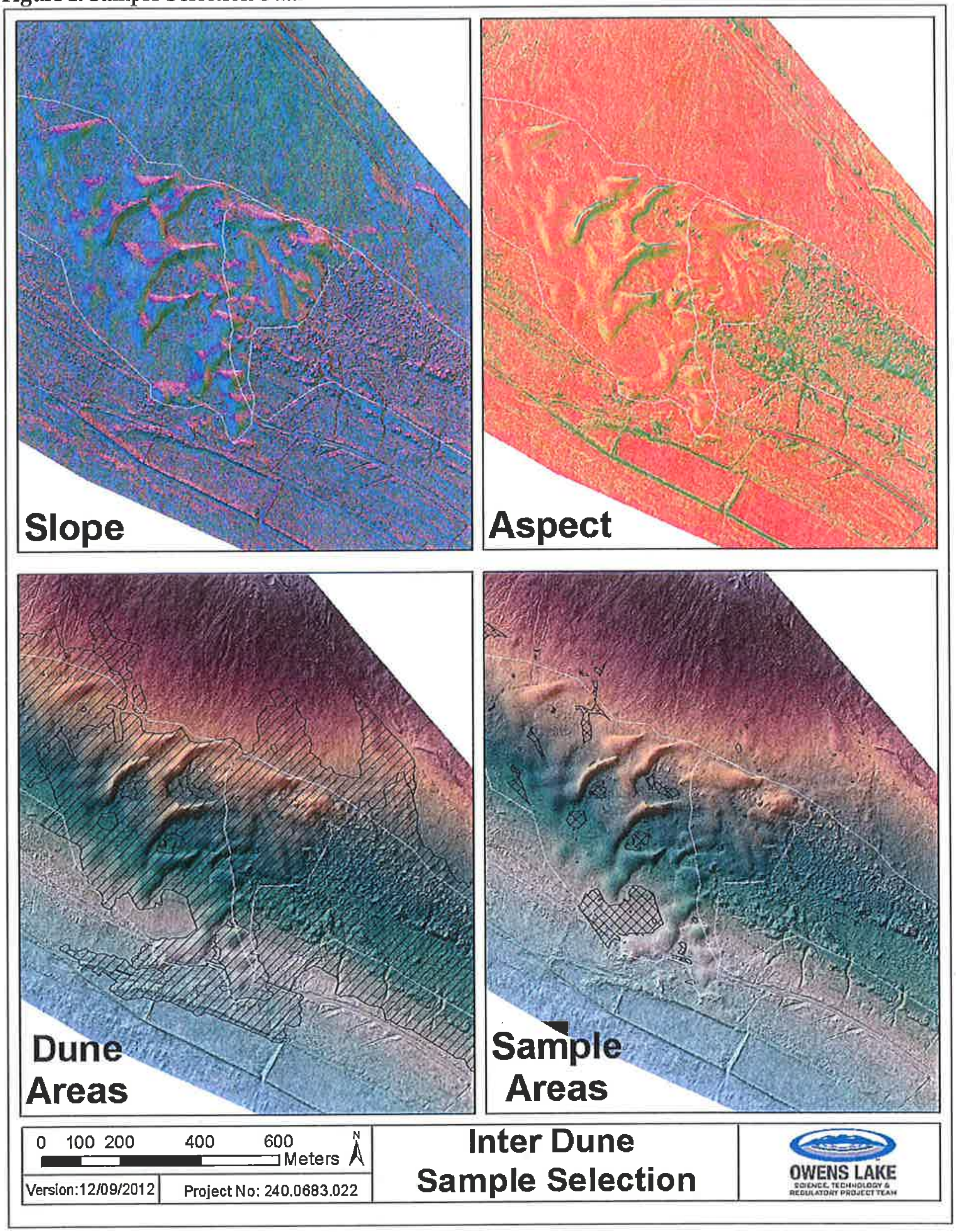


**Figure 2. Interpolated Area**
*Cross hatched areas were used as inputs to the global polynomial interpolation.*

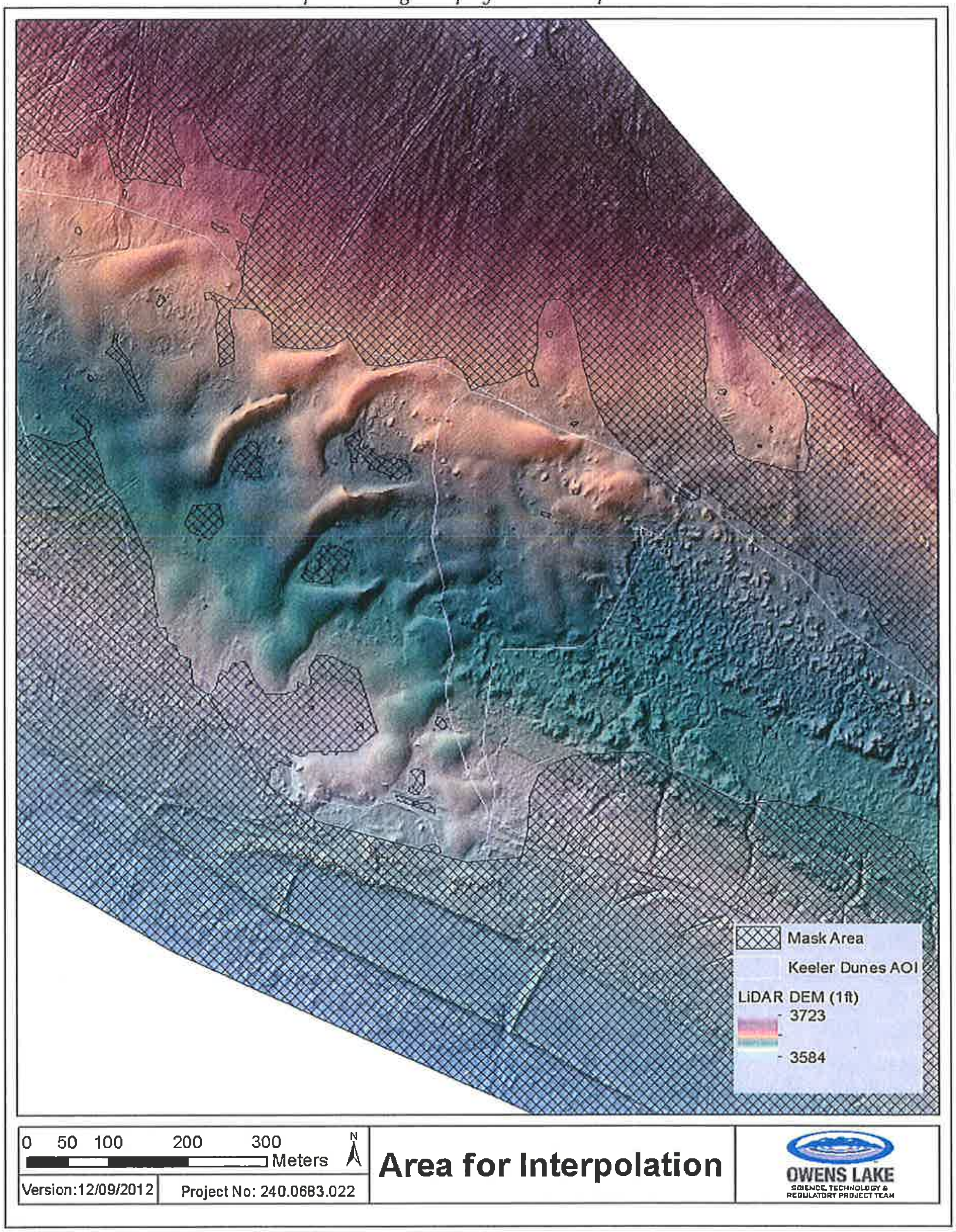
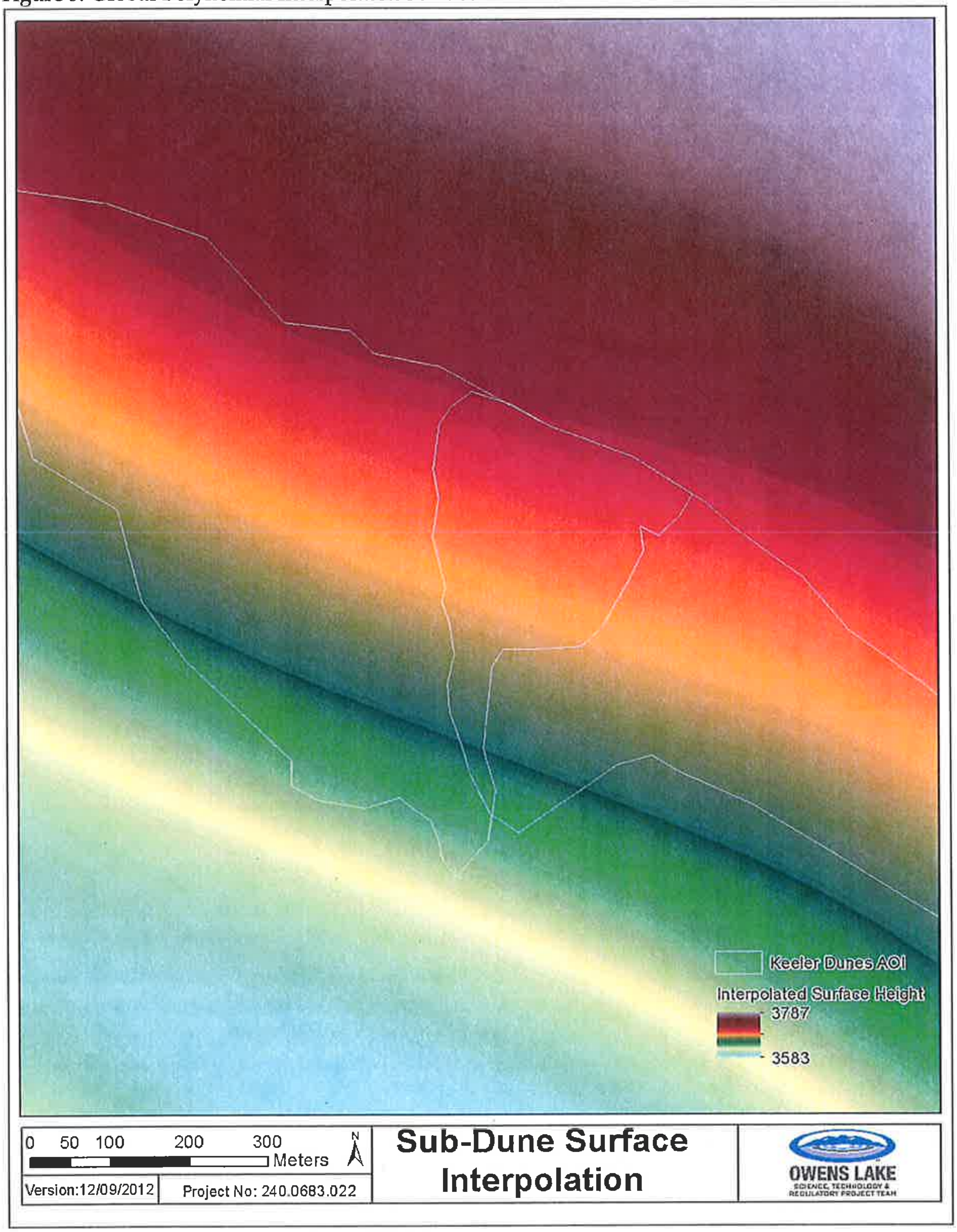


**Figure 3. Global Polynomial Interpolated Surface**



## Results

The difference between the interpolated natural surface and the bare earth digital elevation model was used to determine sand dune height, volume, and mass (Figure 4). Results of this analysis are shown in Table 1. The total sand volume in the primary younger Keeler Dune system was calculated to be 433,923 cubic meters. The total sand volume in the older Keeler Dune system was calculated to be 71,756 cubic meters. These values were used to estimate the potential contribution of the older ablated Keeler Dune strand to the younger Keeler Dunes. Based on this analysis, it is estimated at least 50% of the current primary dune system has been fed by eroded Keeler Dunes (ablation area). This assumes that the eroded Keeler Dunes were similar in mass per unit area to that calculated for the preserved older Keeler Dunes and covered the extent of the delineated ablation area.

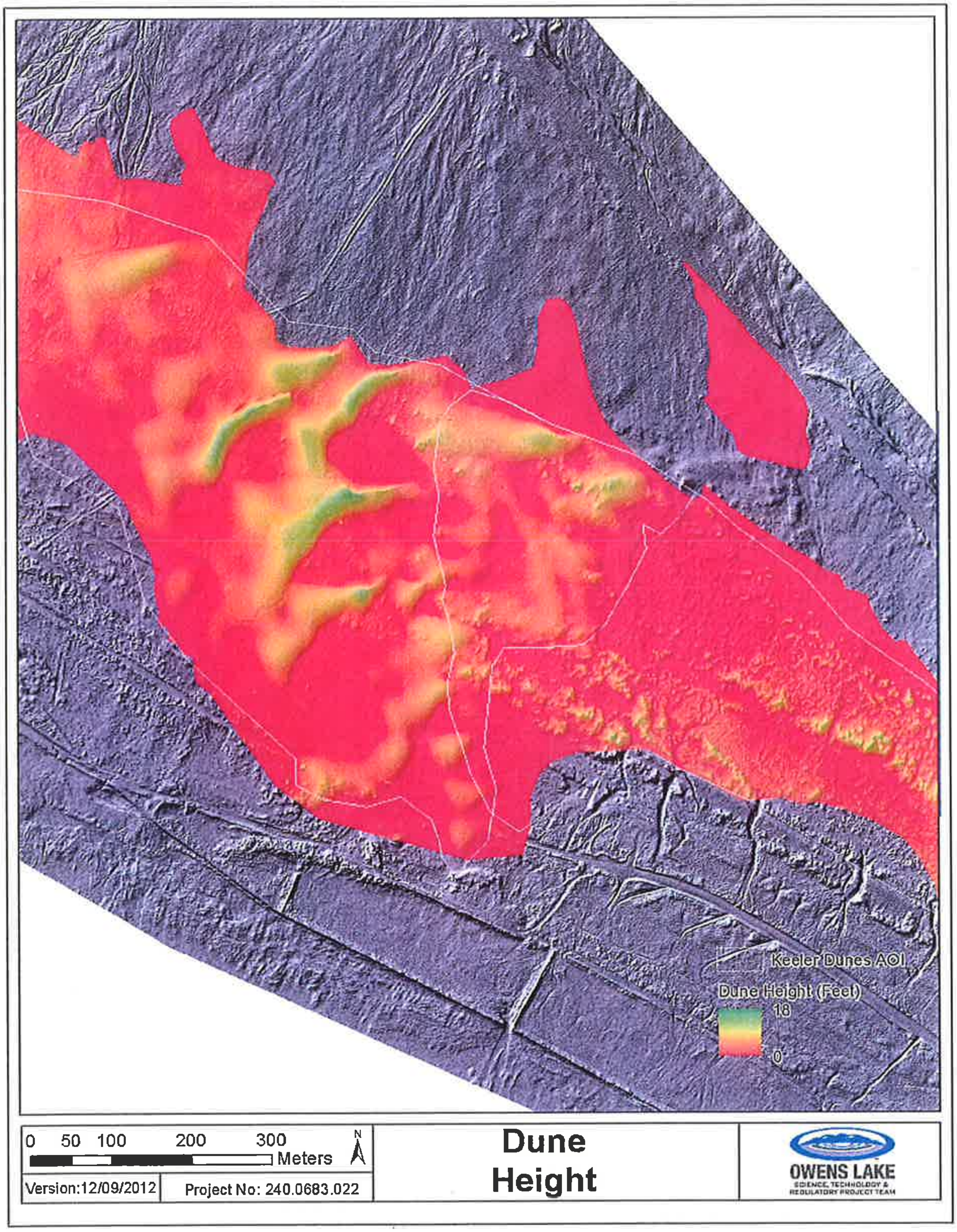
The analysis of the older preserved Keeler dune complex was complicated and contained the bulk of the error within the interpolation model (root mean square error of the natural surface was 2.5 feet). This is likely due to the nature of the old dunes and their small, mounded (almost continuous) shape with very little exposure of the natural ground surface. Based on the observed results, it is probable with refined analysis in this area that the typical volume of the older dunes is greater than currently calculated. A volume up to 30% greater is expected with refined input data and would indicate as much as 70% of the current primary dune system could have been fed by eroded older Keeler Dunes. These analysis refinements are in progress.

**Table 1. Results of Sand Volume and Mass Calculations in the Keeler Dune Complex and Calculations of Possible Aeolian Sand Contribution from the Ablated Keeler Dune Strand**

| Area | Area (ac) | Volume ($ft^3$) | Volume ($m^3$) | Mass ($kg/m^3$) | Average Mass per Acre |
|---|---|---|---|---|---|
| *Younger Dune System* | | | | | |
| North Dune | 5.4 | 253,707 | 7,184 | 11,853,765 | 2,177,222 |
| Horseshoe Dune | 34.0 | 1,631,165 | 46,189 | 76,212,510 | 2,243,376 |
| Linear Dune | 16.8 | 3,591,809 | 101,709 | 167,819,355 | 10,010,765 |
| Total Younger Southern Keeler Dunes | 98.0 | 9,845,902 | 278,841 | 460,088,895 | 4,694,259 |
| *Southern dune part without overlap* | *78.4* | *8,129,670* | *230,207* | *379,840,890* | *4,846,282* |
| *Southern dune part overlapping old dunes* | *19.6* | *1,986,972* | *56,265* | *149,101,455* | *7,594,364* |
| *Mass within overlapping area representing buried old dunes* | | | | *68,853,450* | |
| *Mass within overlapping* | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| *area representing new sand* | | | | *80,248,005* | |
| **Total Younger Keeler Dunes (excludes sand sheet/coppice aeolian deposits)** | **154.2** | **15,321,855** | **433,923** | **715,974,525** | **4,643,410** |
| *Old Dune System* | | | | | |
| Preserved Older Keeler Dunes | 54.2 | 2,534,051 | 71,756 | 190,154,195 | 3,506,996 |
| Ablation Area - mass eroded aeolian sand if similar in volume to preserved older Keeler Dunes | 103.0 | 7,732,580 | 218,991 | 361,335,512 | 3,506,996 |

**Figure 4. LiDAR Digital Elevation Model (DEM) Minus Interpolated Surface.**



## References

Pye, Kenneth, Haim Tsoa; and Tsoar, 1974. Aeolian Sand and Sand Dunes.