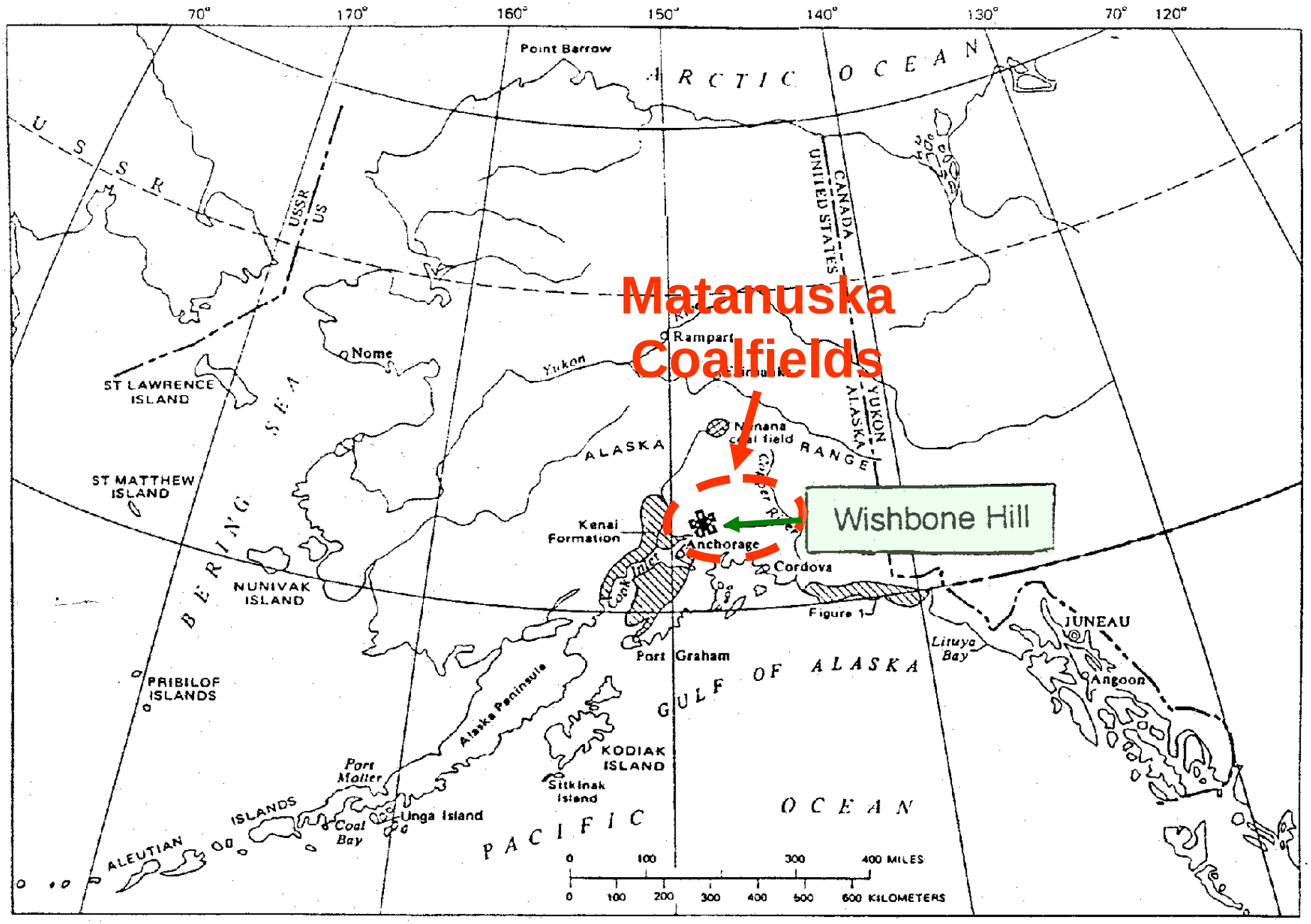
Geospatial applications in the Alaska AML Program

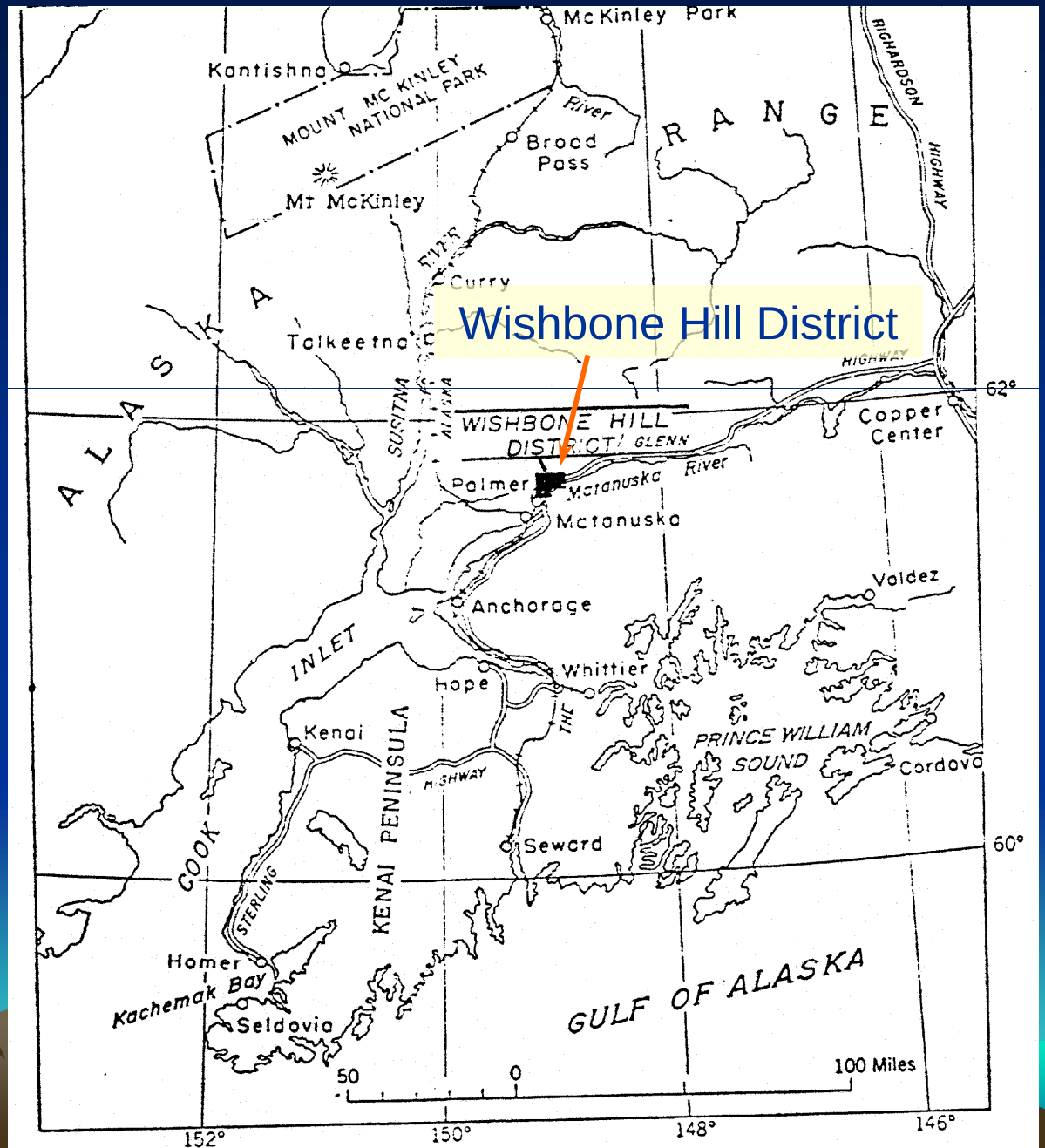
Examples & Practical Results from an Alaskan User's Perspective

Roger Allely
Alaska AML Program

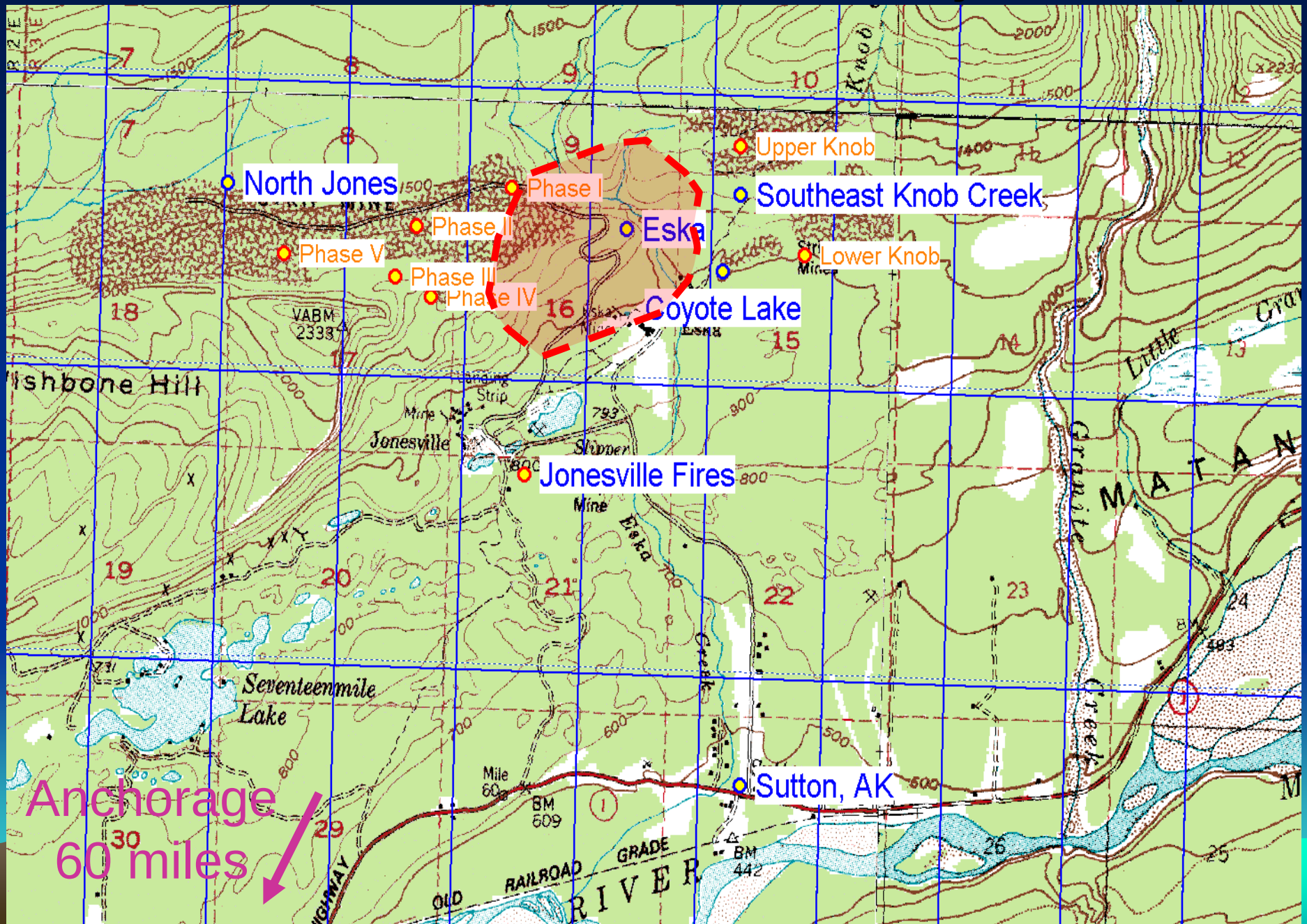
State Location map – WB/Jones/Knob



Cook Inlet area --Location map



Sutton Area Coalfields -- Project Map



Eska Inventory -- October 2005

Multiple seams underground mined in Eska and Jonesville from 1910s through 1940s

Variety of mining hazards left behind

- shafts, adits, subsidence features, hazardous equipment and facilities

Eska Inventory -- October 2005

Early AK AML Program Work

Eska Reclamation

Mid -1980s

- Main adits closed, spoils reshaped
- Eska Wash Plant --HEF & buildings removed

1993 -- several dangerous shafts closed along North Jones Road

Eska Inventory -- October 2005

Desire to document remaining hazards in Eska / Jonesville area

Target descriptions compiled from maps and literature by AML staff

- ~70 targets were located on a CAD layer

Eska Inventory -- October 2005

Reconnaissance map preparation

CAD layer targets exported as shapefile to GIS for Arcpad use

A ‘Found AML features’ point file created in Arcpad

- created forms for data entry
- allowed export of attribute data to a GIS shapefile table
  - dimensions, condition, time of visit

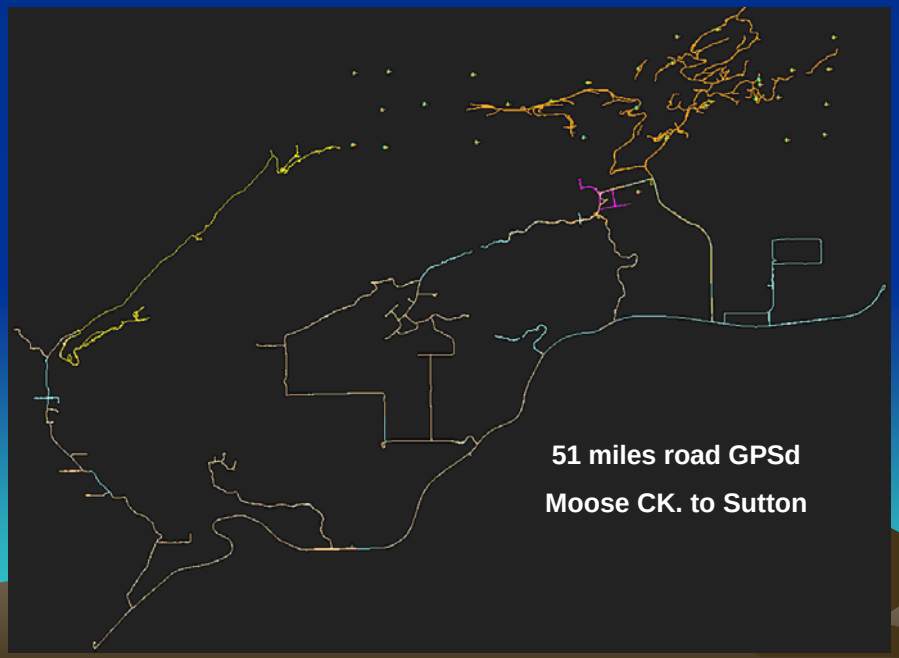
Eska Inventory -- October 2005

Raster backgrounds generated

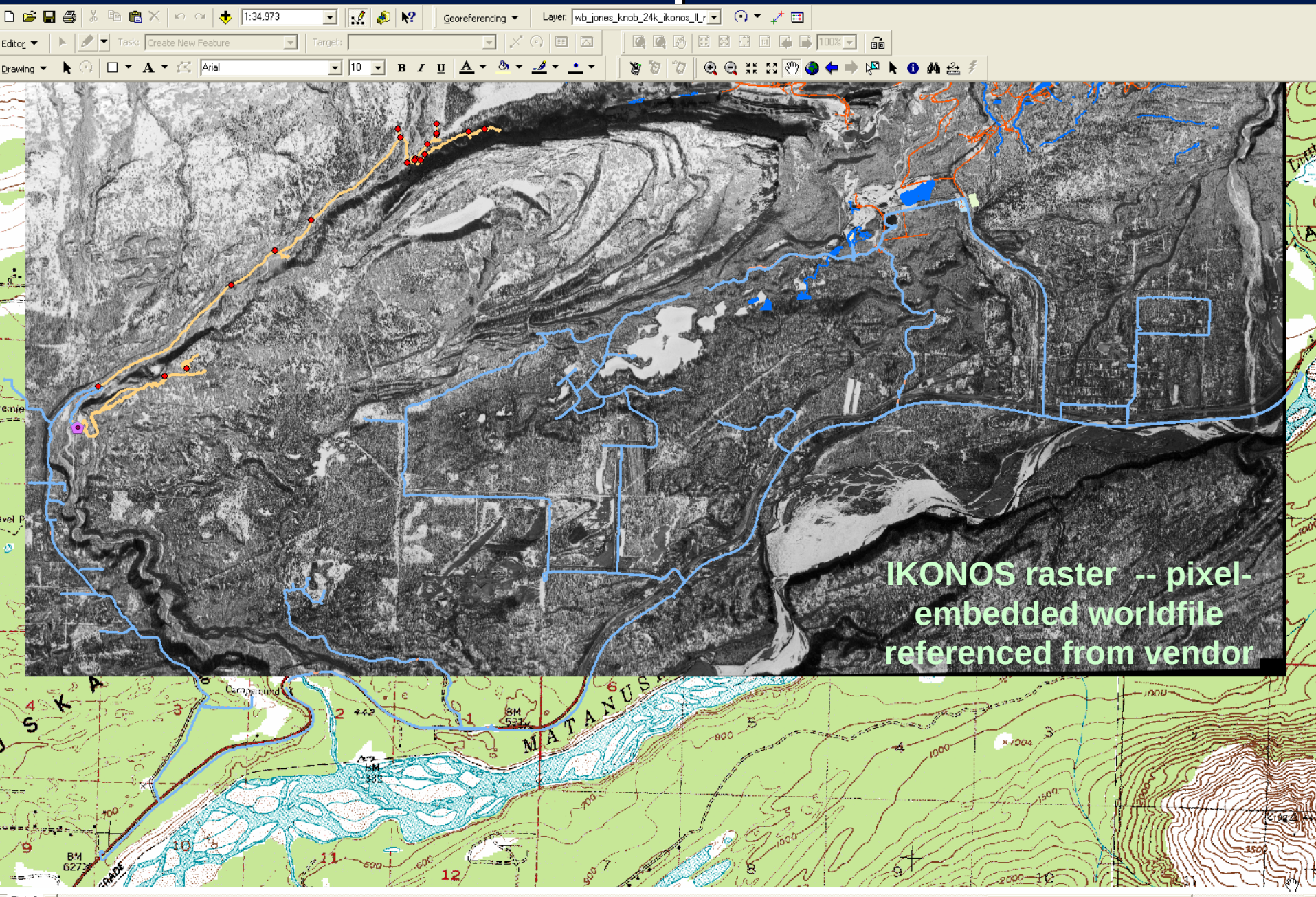
- IKONOS image subset, reprojected, polynomial-corrected in ERDAS
- 1943 USGS plate 1016 Eska mine map scanned and georeferenced

Images converted to TIFF and MrSid for Arcpad use.

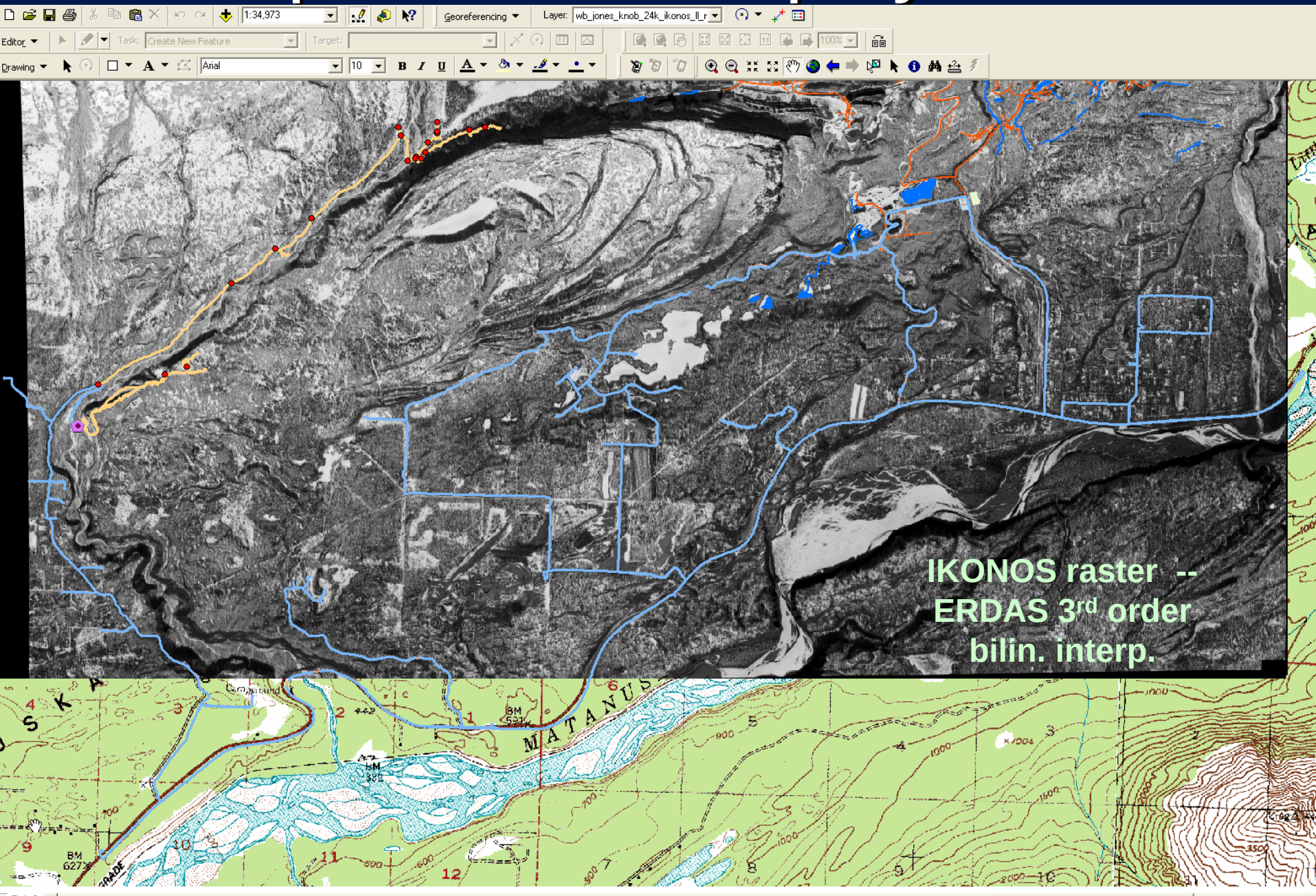
Examples – Vector collection



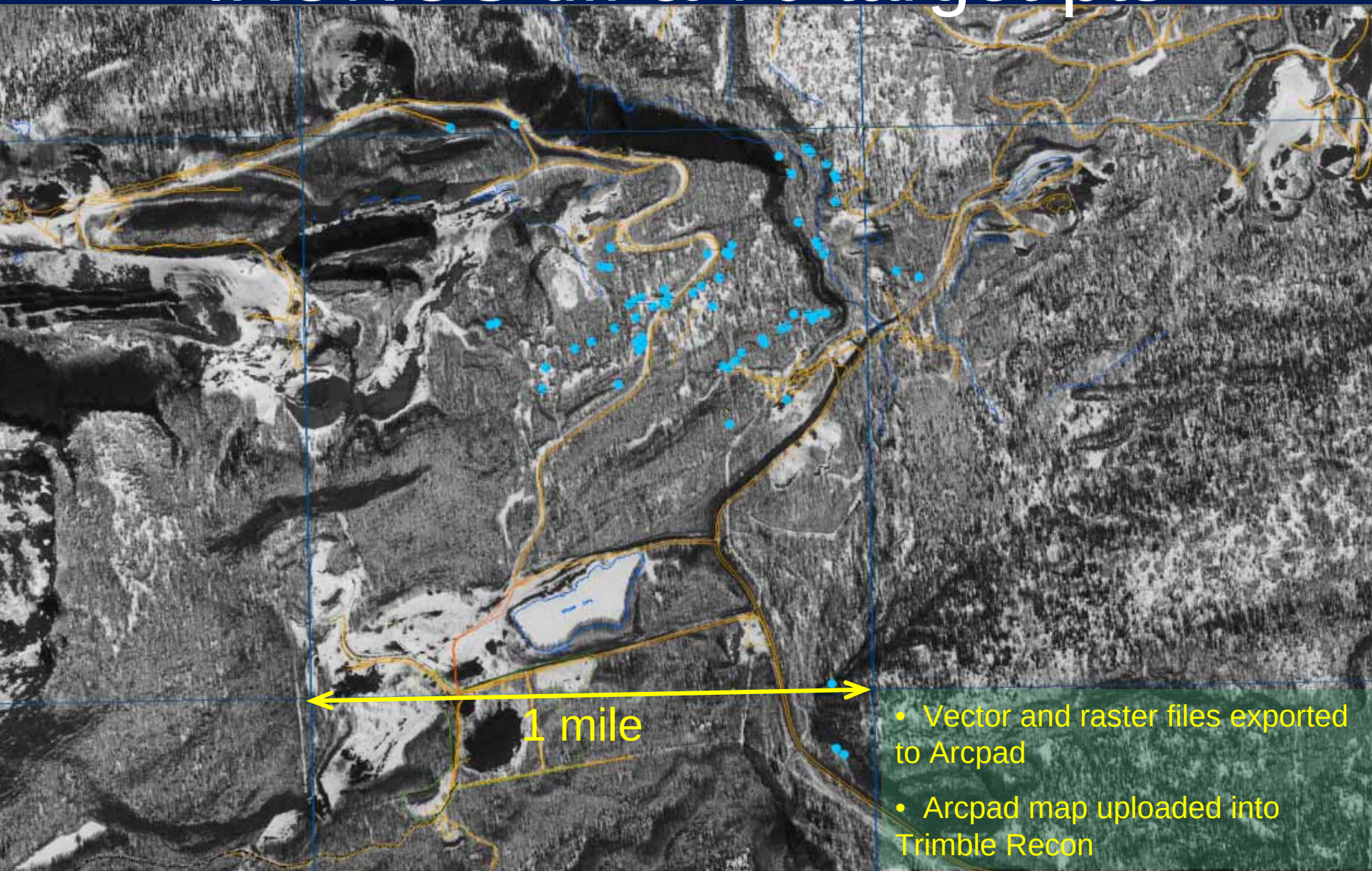
IKONOS Raster -- pseudo-corrected



Examples – Raster poly-correct.

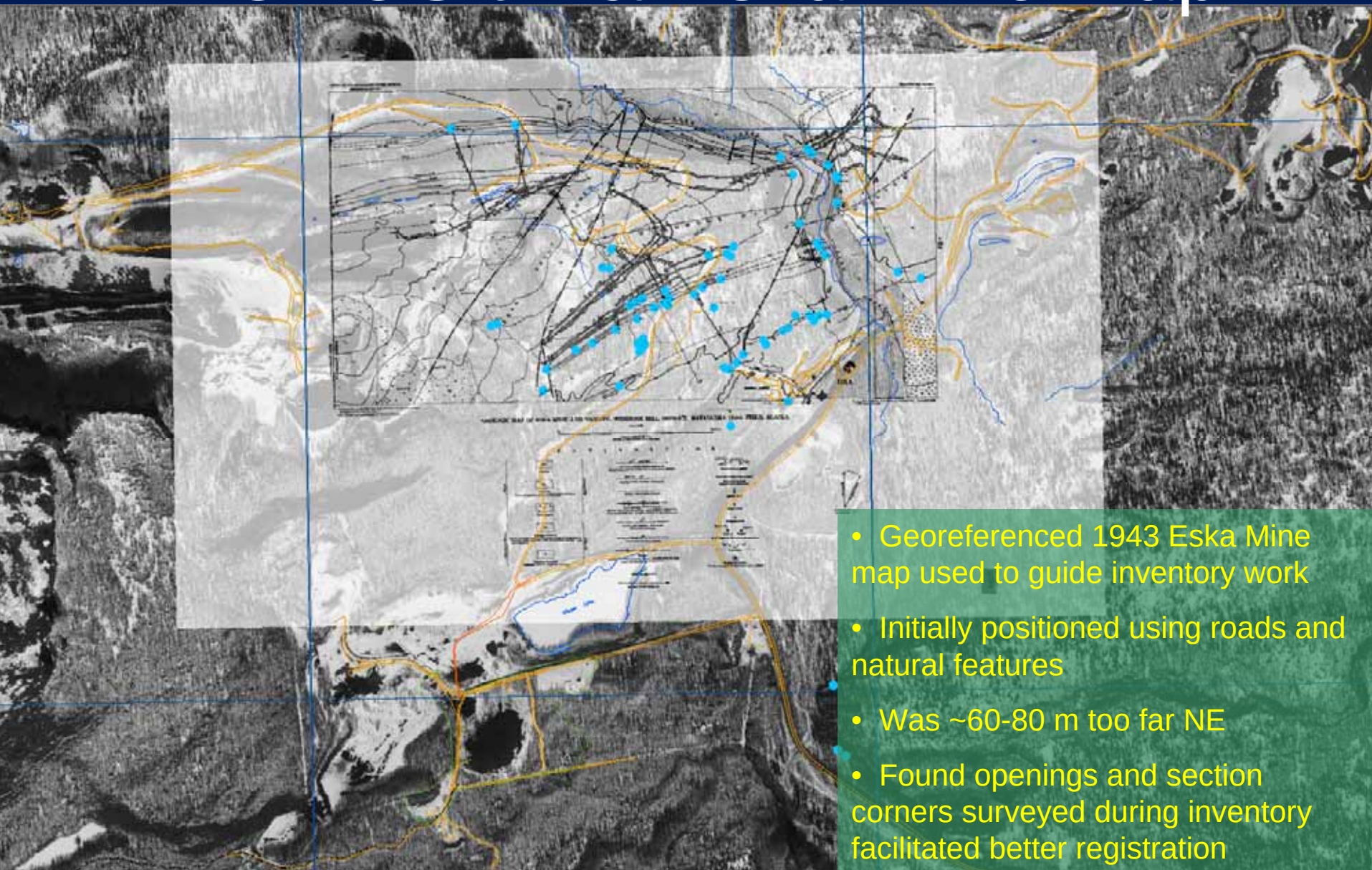


Eska Inventory -- October 2005
IKONOS tiff & 70 target pts



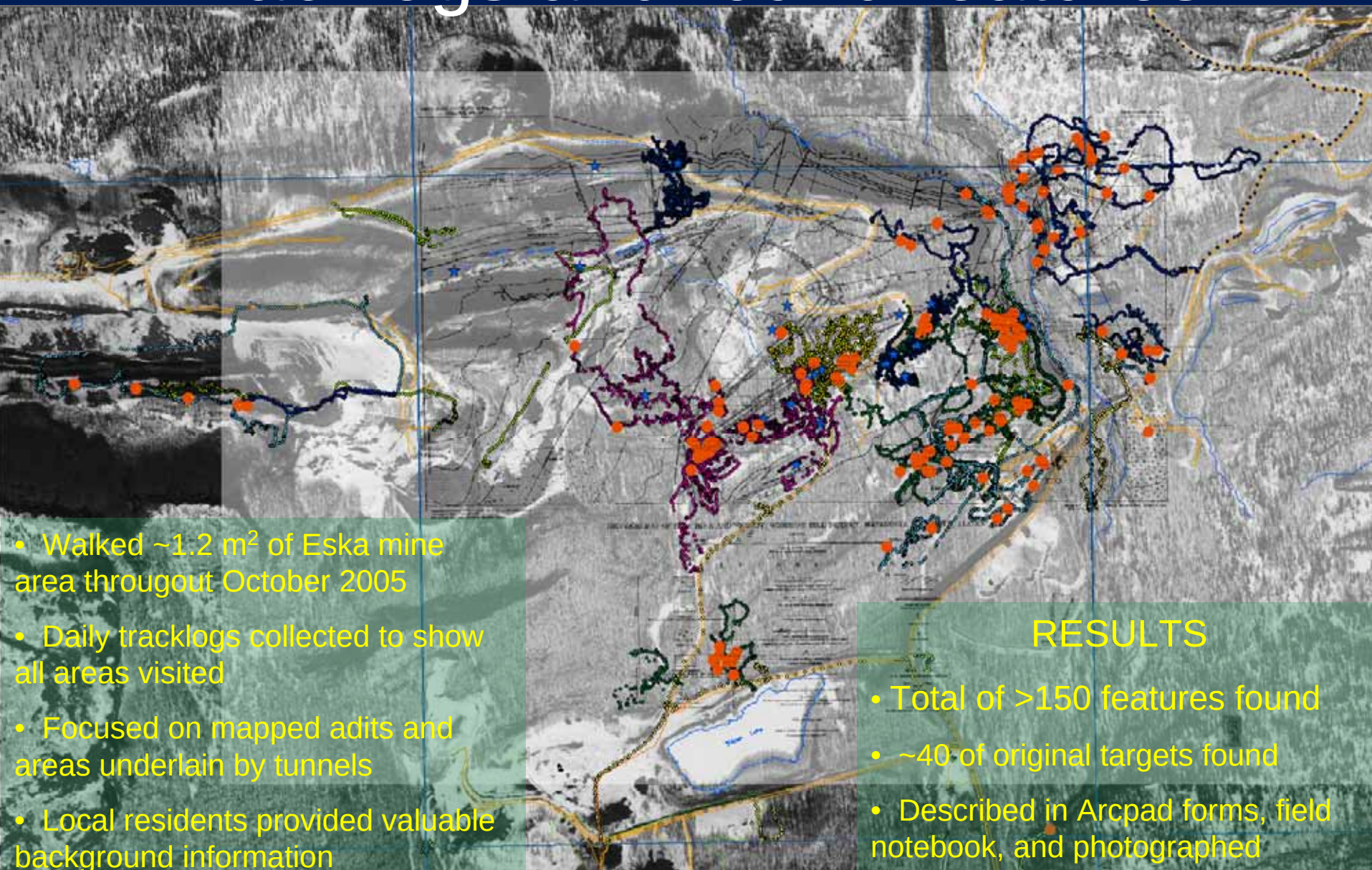
- Vector and raster files exported to Arcpad
- Arcpad map uploaded into Trimble Recon

Eska Inventory -- October 2005
IKONOS tiff & Eska Mine map



- Georeferenced 1943 Eska Mine map used to guide inventory work
- Initially positioned using roads and natural features
- Was ~60-80 m too far NE
- Found openings and section corners surveyed during inventory facilitated better registration

Eska Inventory -- October 2005
Tracklogs and found features

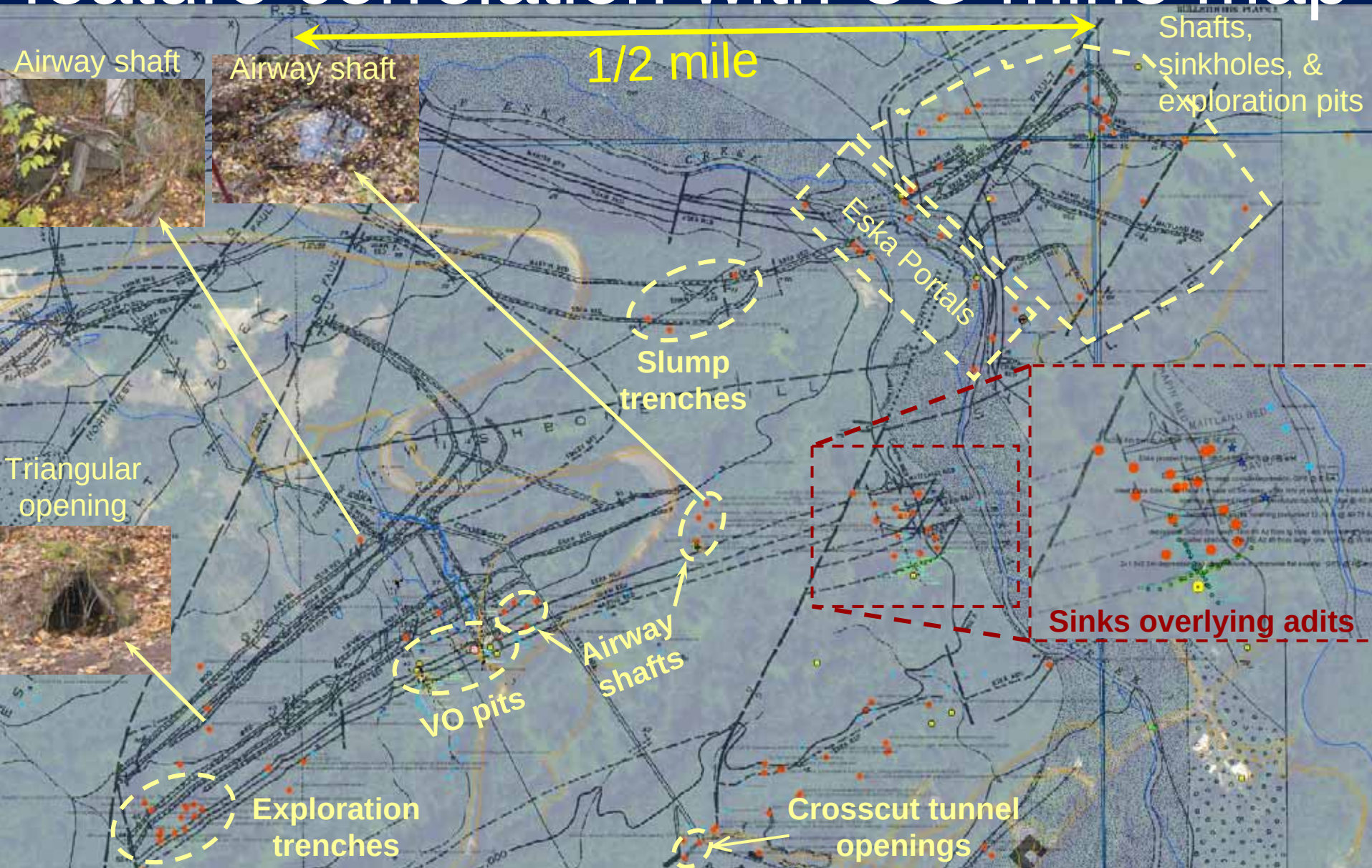


- Walked ~1.2 m^2 of Eska mine area througout October 2005
- Daily tracklogs collected to show all areas visited
- Focused on mapped adits and areas underlain by tunnels
- Local residents provided valuable background information

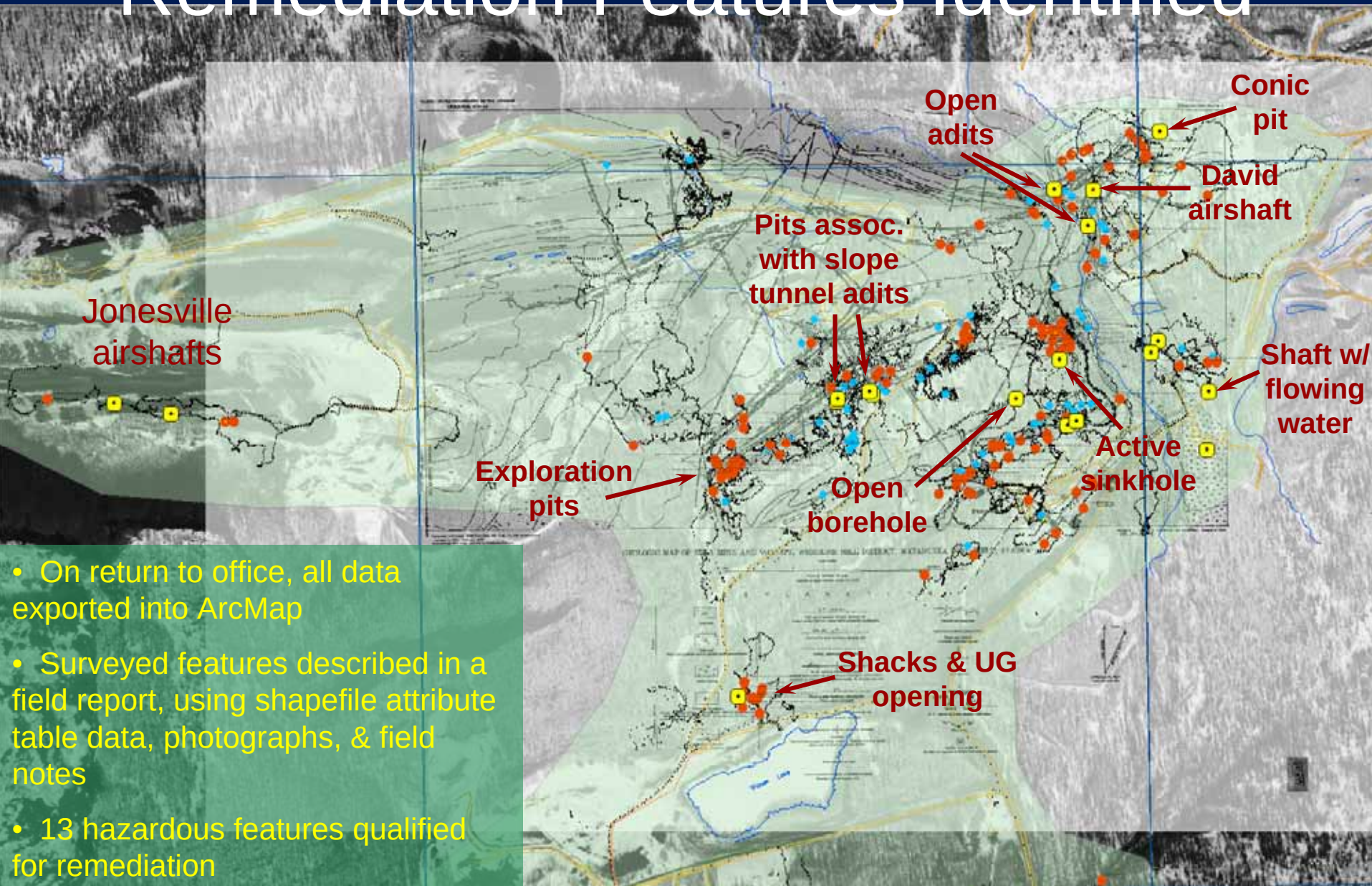
RESULTS

- Total of >150 features found
- ~40 of original targets found
- Described in Arcpad forms, field notebook, and photographed

Inventory work – GPS-located feature correlation with UG mine map



Eska Inventory -- October 2005
Remediation Features Identified



- On return to office, all data exported into ArcMap
- Surveyed features described in a field report, using shapefile attribute table data, photographs, & field notes
- 13 hazardous features qualified for remediation

Inventory work – October 2005
Remediation Features Identified

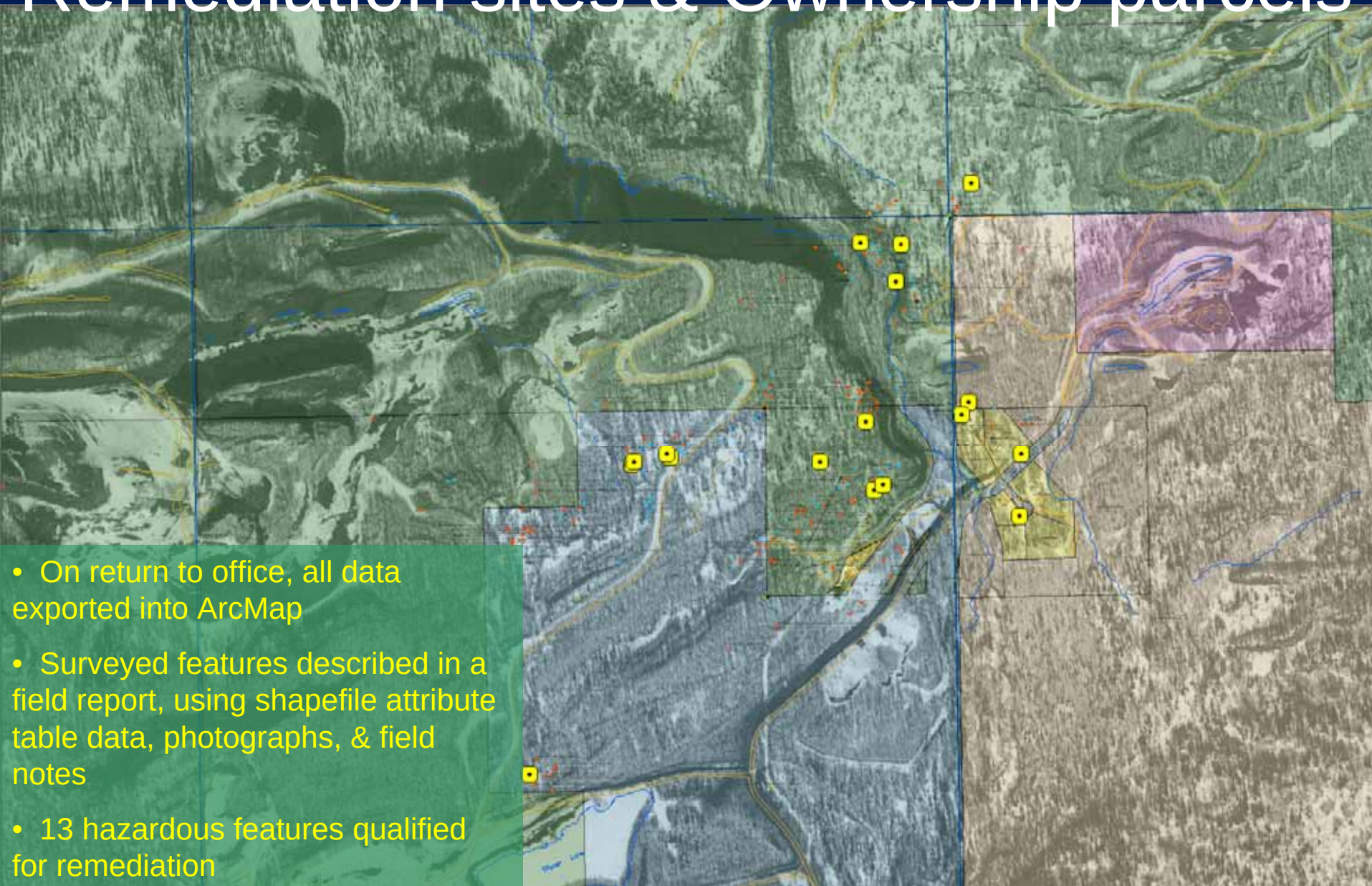
Hazards Qualifying for Remediation

- Seven partially filled airshafts with vertical drops of 6-12 feet
- one 10-foot deep active sinkhole
- one water-filled shaft

Remediation candidates (cont'd.)

- one framed UG opening
- Two adits in Eska Ck. Canyon being kept open as active bear dens (1/4 mile from residences)

Eska remediation Planning
Remediation sites & Ownership parcels



- On return to office, all data exported into ArcMap
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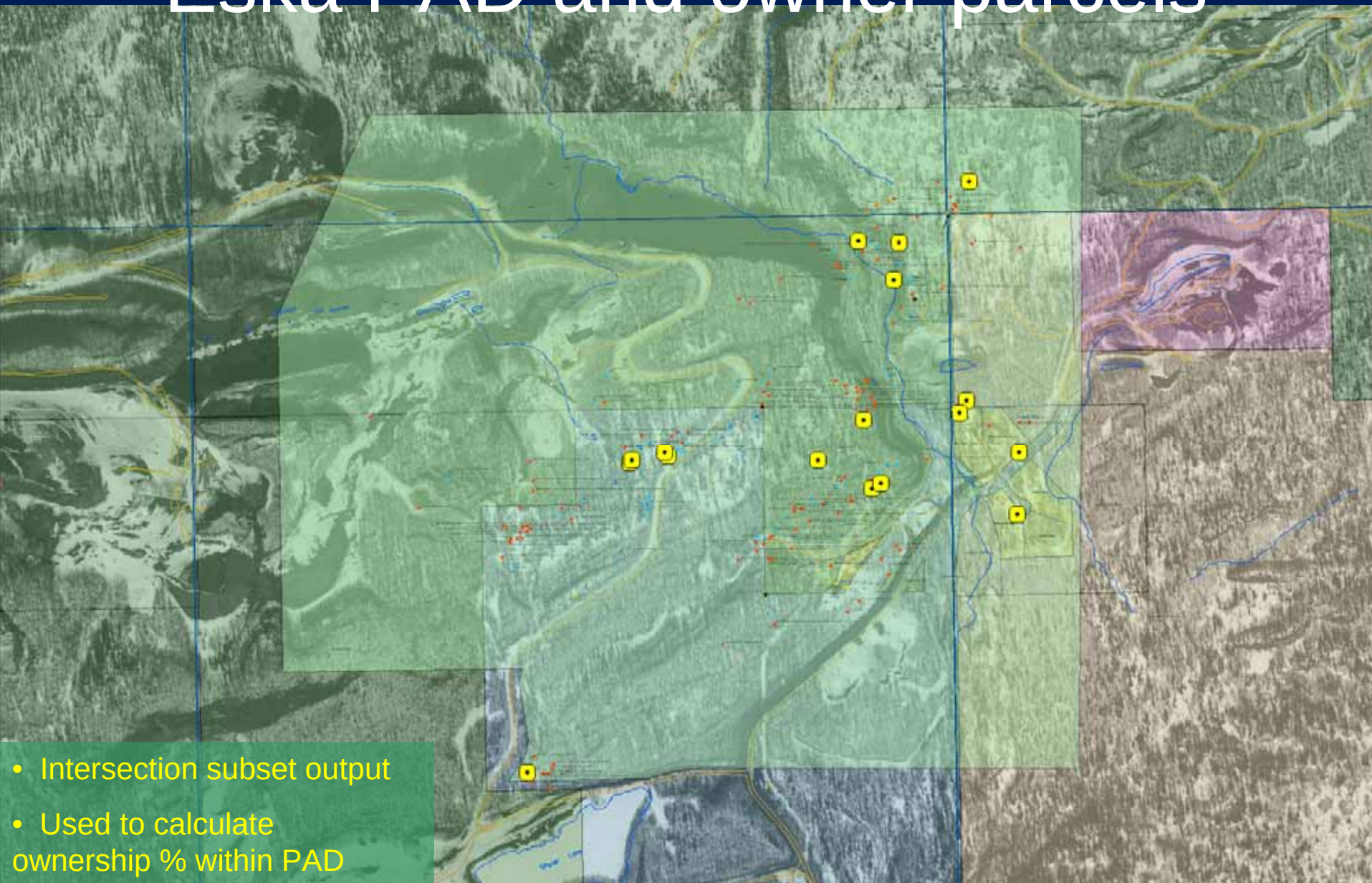
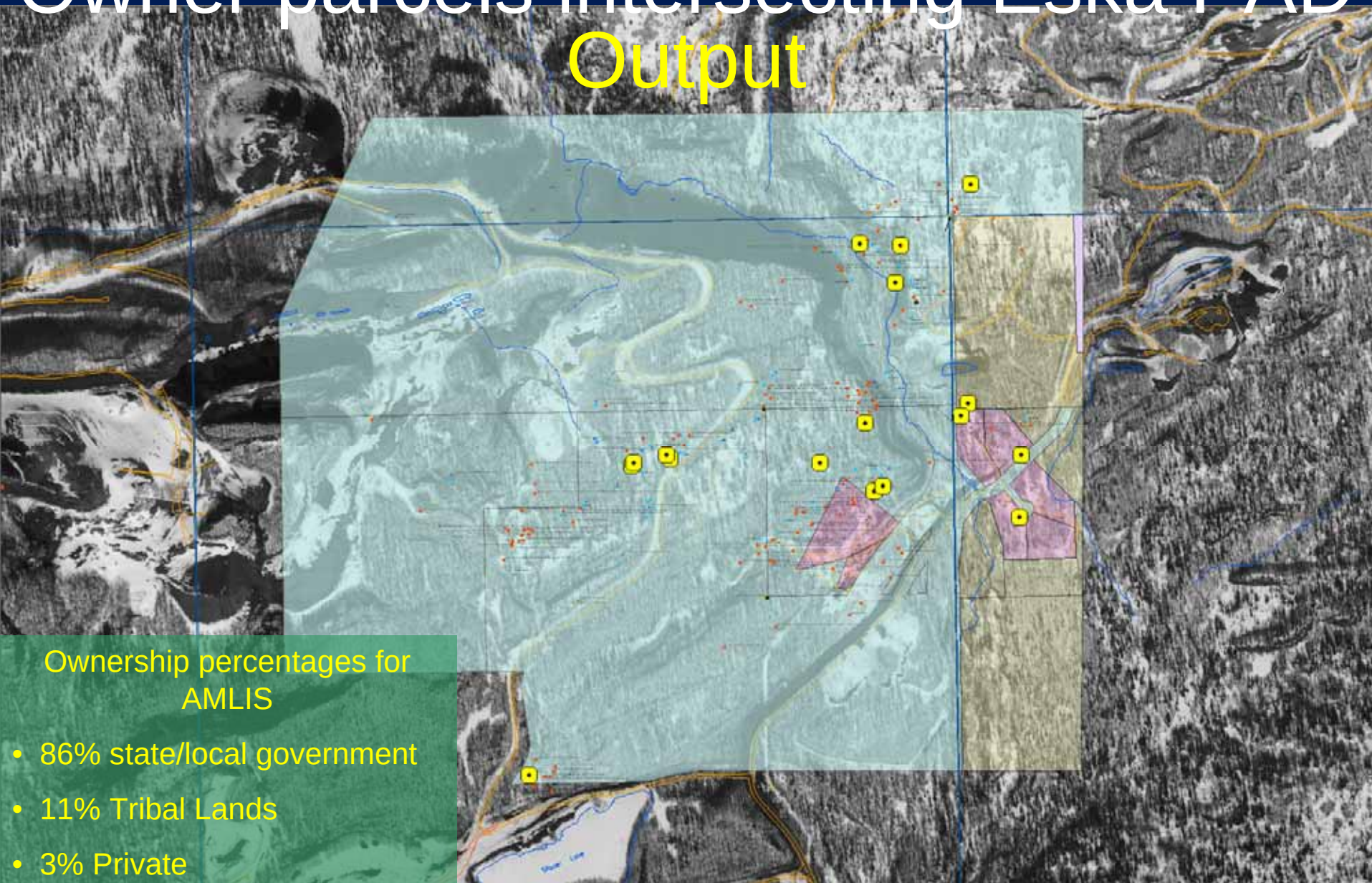
Eska Remediation Planning
Eska PAD and owner parcels



- Intersection subset output
- Used to calculate ownership % within PAD

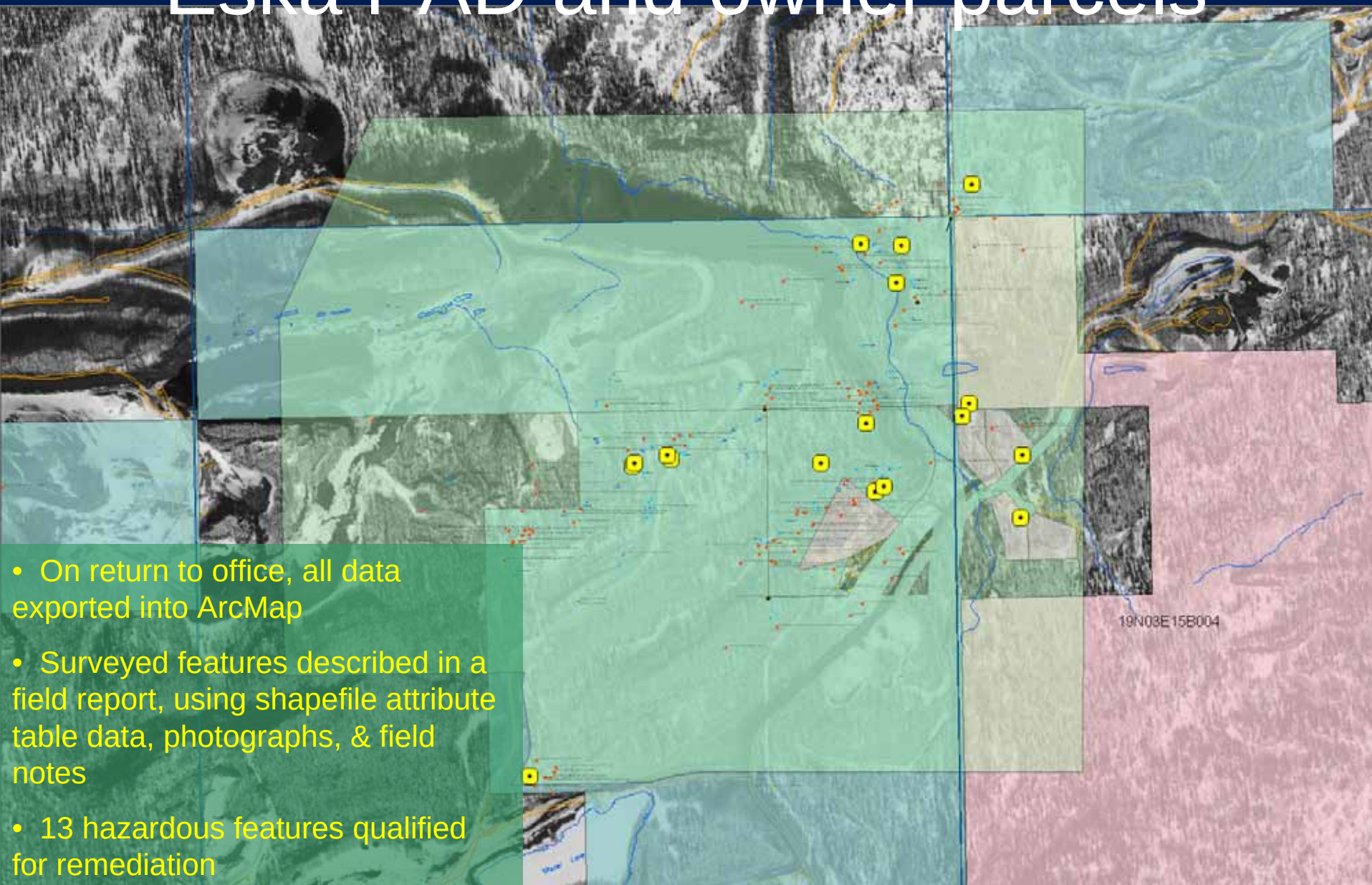
Eska remediation Planning
Owner parcels intersecting Eska PAD
Output



Ownership percentages for AMLIS

- 86% state/local government
- 11% Tribal Lands
- 3% Private

Eska remediation Planning
Eska PAD and owner parcels



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- Surveyed features described in a field report, using shapefile attribute table data, photographs, & field notes
- 13 hazardous features qualified for remediation

Eska remediation Planning
Parcels containing AML sites

- Parcel ownership determined to obtain right of entry consent

Jones & Eska Project Sites

Inventoried October 2005

Airshaft Trench

Airshaft 6m E of ATV trail – July 2005

Framed UG opening

Subsiding N. Jones Airshaft

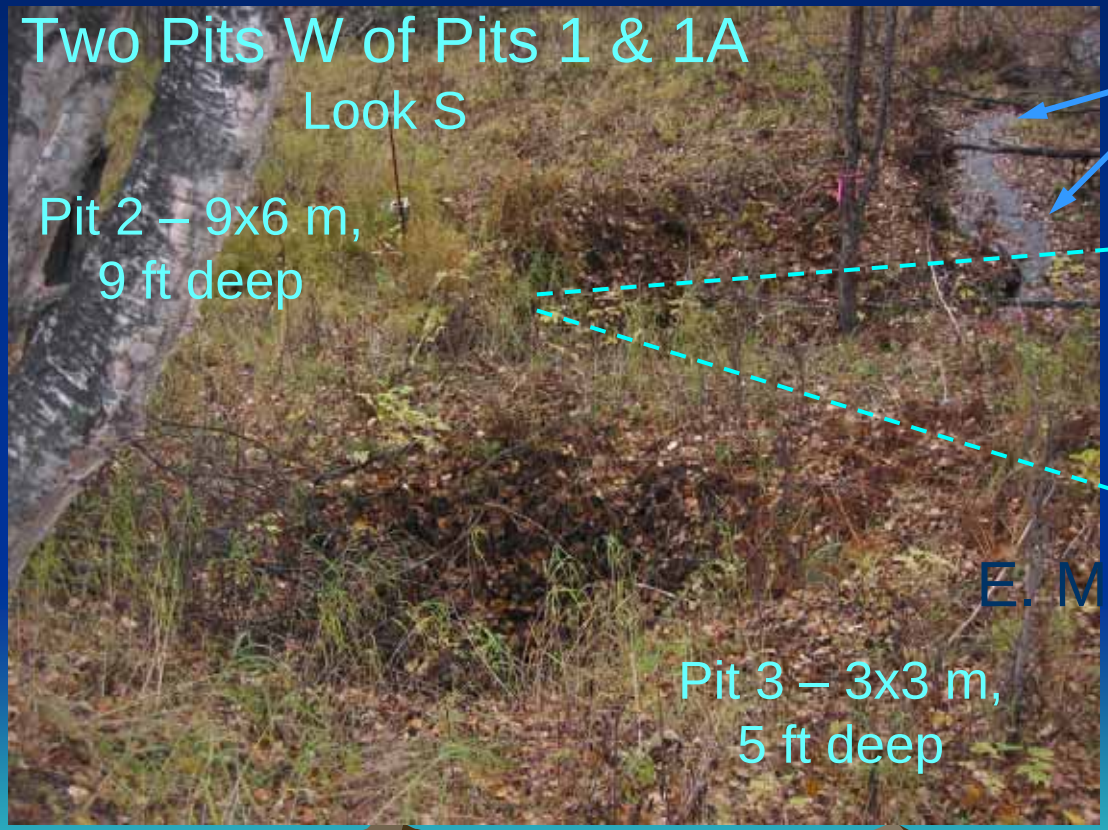
Water-filled shaft – flowing

1998 – hoist ruins aboveground

Oct. 2005 –ruins collapsed into pit

15 ft. deep & growing

Eska Project Sites
Inventoried October 2005



Creek

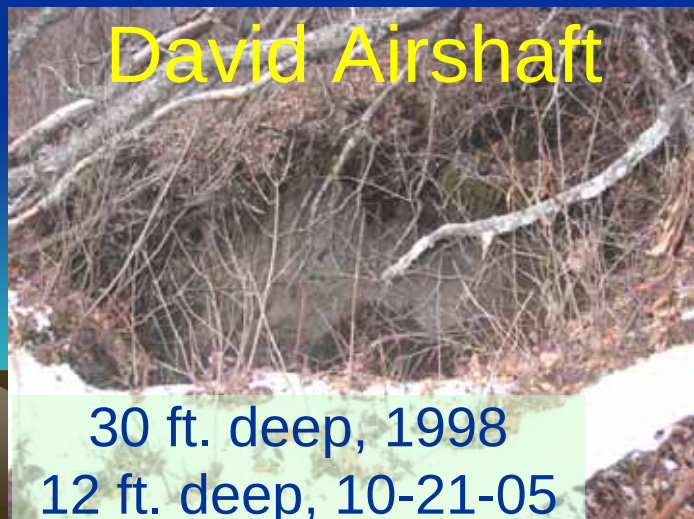
Eska Project Sites
Inventoried October 2005

Conic subsidence pit

8” Open borehole next to ATV trail

10 ft. deep sinkhole above Eska adits

Collapsed Portals along RR grade



30 ft. deep, 1998
12 ft. deep, 10-21-05

Inventory – Shacks in Gorderville

East Shack

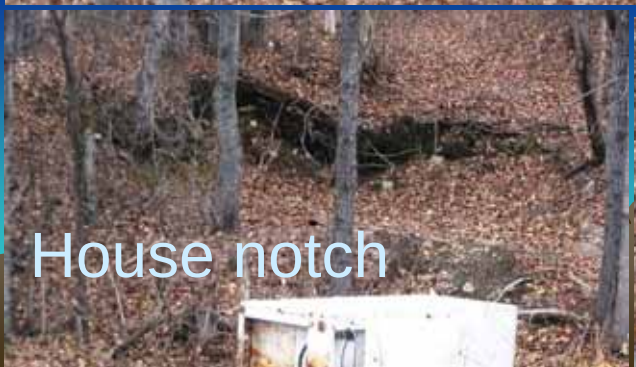
Pipe to UG tank?

Trailer Lean-to

Tarpaper shack

4" csg in house notch

House foundation


House notch

Framed UG opening

Subsidence above UG opening

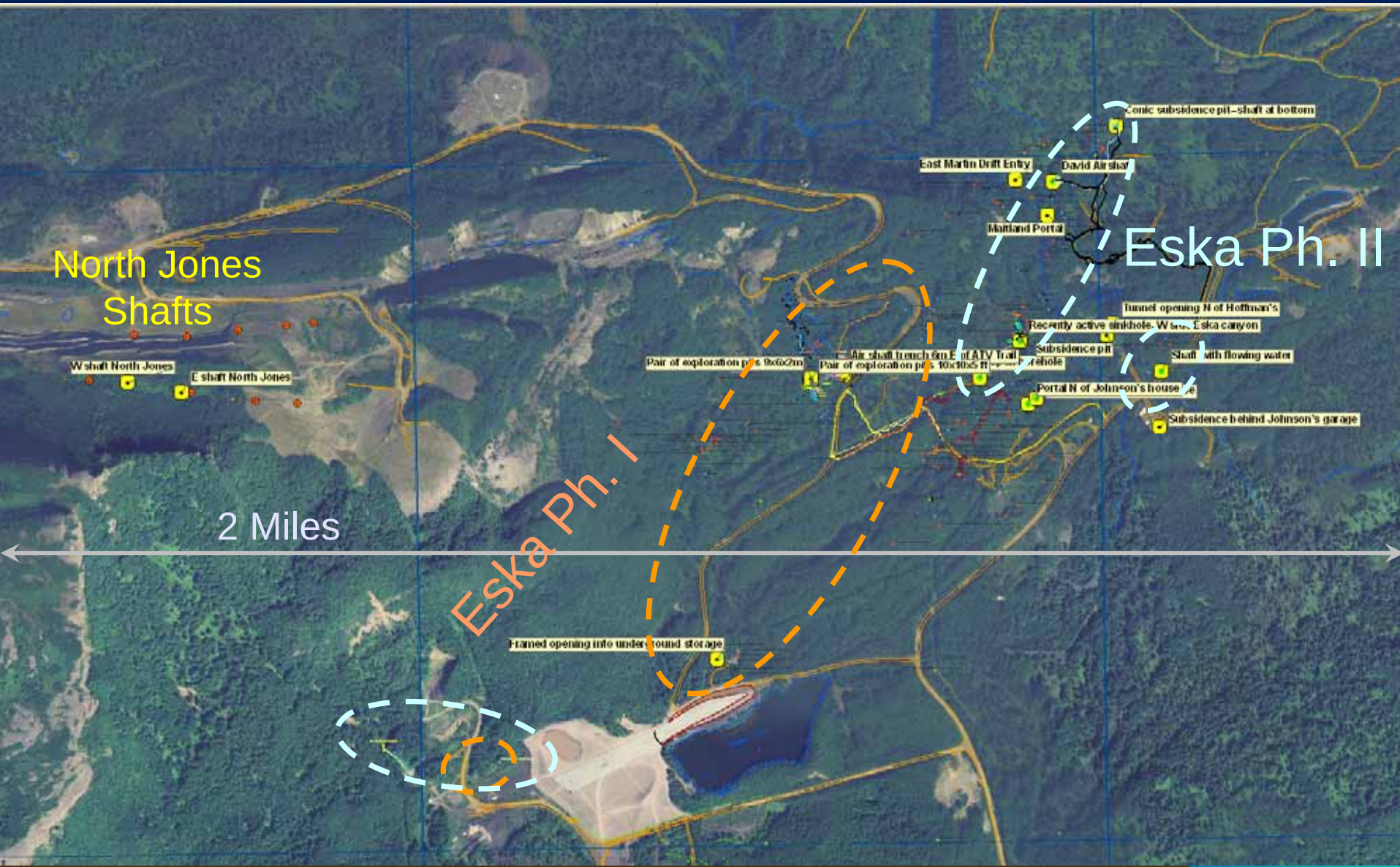
Inventory – Adit Portals at Eska

E. Martin Drift, 5-6-98

E. Maitland portal 4-28-04

Shaw Drift, ca. 1998
(now collapsed)

Remediation – May - October 2007
Eska Phases I & II



Eska Remediation Design
VO / Subsurface considerations

Our program planned to close 8 Eska area vertical openings in 2007

- Surface depressions 6-13 ft. deep
- Some exhibited soft bottom zones
- BR known to be shallow beneath some, suspected to be beneath others
- overlain by unconsolidated overburden

Eska Remediation Design
VO / Subsurface considerations

Experts advise designers closing VOs determine depth to bedrock or shaft collars overlain by unconsolidated overburden

- Openings act as control surfaces in case of catastrophic overburden collapse.
- Illustrated by the 1982 Pinebrook shaft incident)

Eska Remediation Design
VO / Subsurface considerations

AK AML decided against a separate exploration drilling program to determine opening depths and dimensions

- Decided to combine exploration and remediation phases
- Rather, excavate to daylight openings, stopper with boulders, backfill with graded aggregate

Eska Remediation Design
VO / Subsurface considerations

Decided I needed to know BR depth around raveling or recently active features, to

- Determine safe surface setback distances, using angle of repose of overlying materials
- Determine digging depths to properly size equipment

Eska Remediation Design
Seismic Refraction survey

October 2006 -- Surveyed six seismic refraction lines around three closure sites

- 6-foot deep ATV pit
- Pair of pits 6 and 9 feet deep
- 10- ft. deep recently active sinkhole

Eska Remediation Design
Seismic Refraction survey

- Two spreads surveyed at each site, crossing at near right angles near target openings
- Geophone spacing varied from 4-10 ft., based on line length
- Shot energy generated with 4-lb. sledge striking an aluminum plate

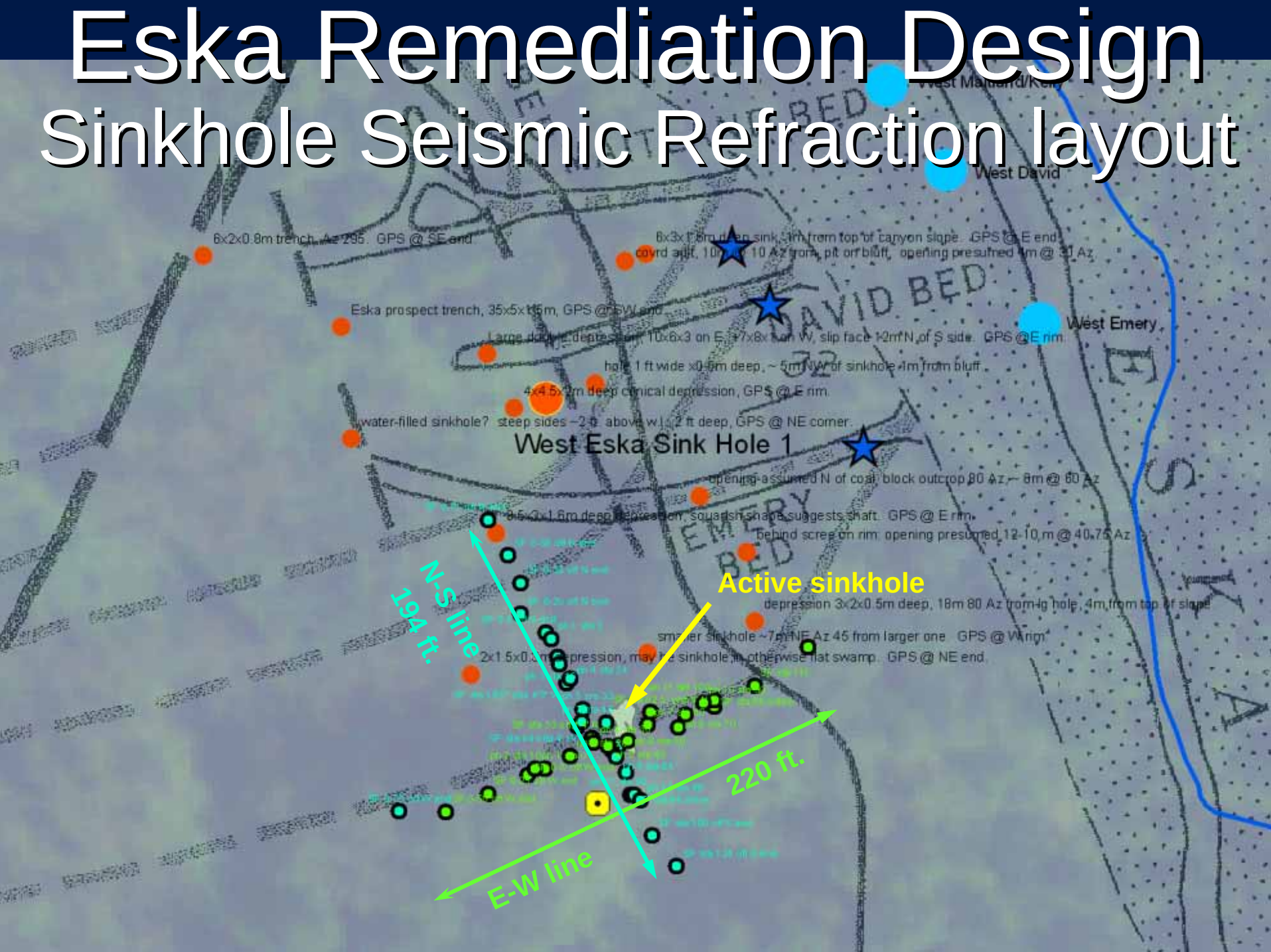
Eska Remediation Design
Seismic Refraction survey

- Geometrics 12-channel ES-1225 used to gather first-arrival data
- Shots stacked to optimize returns
- Geophone traces & acquisition parameters output to printer tapes
- First-arrival times noted on printer tapes in field, w/ aid of seismograph display

Eska Remediation Design
Seismic Refraction survey

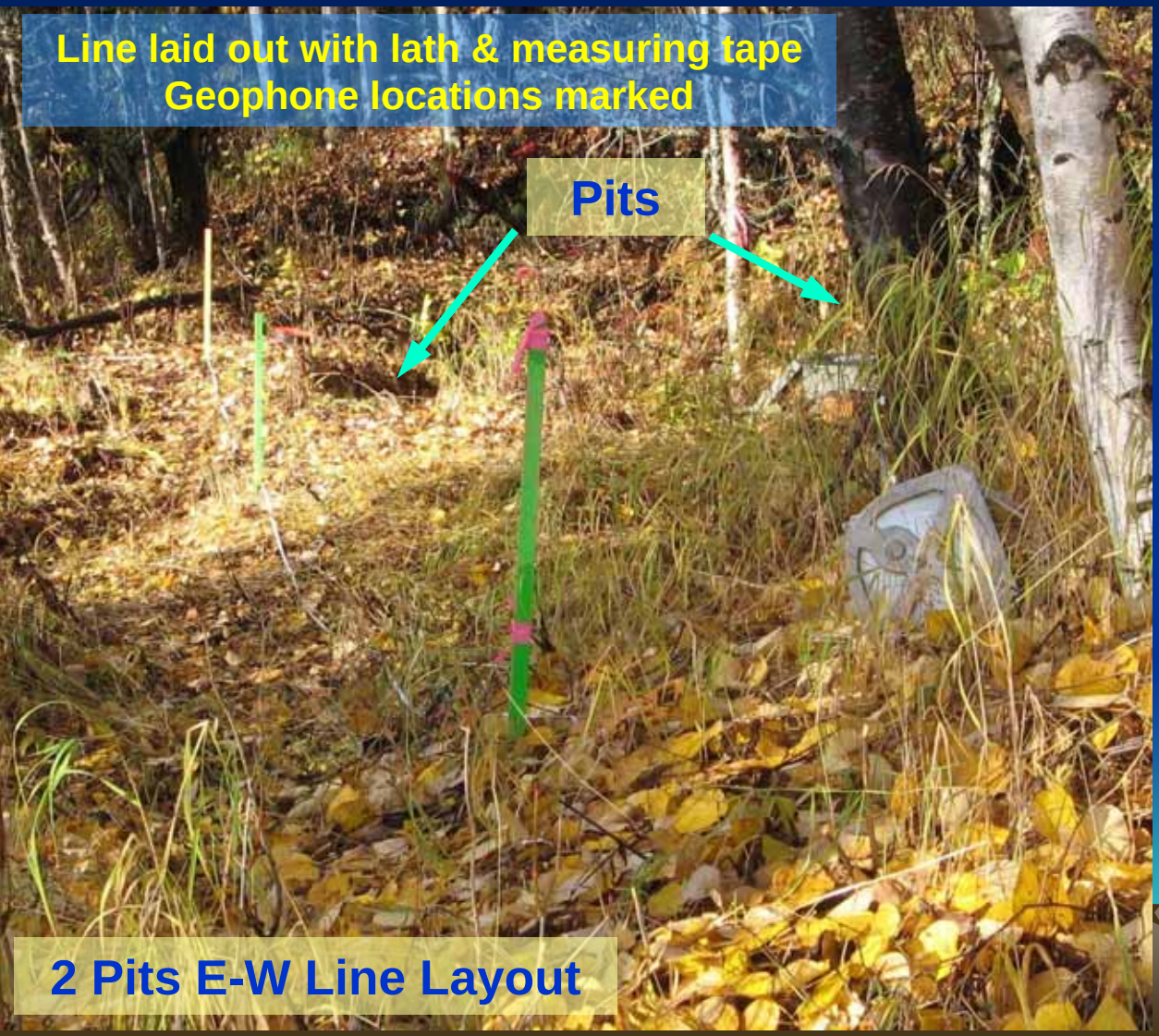
- Shots fired on line ends, off the ends, and spaced within line interiors
- Assured overlap of 1st arrivals from each refractor in both directions
- Facilitates delay-time depth computations for each interface, beneath each geophone.

Eska Remediation Design
Sinkhole Seismic Refraction layout



Eska Remediation Design
Seismic Refraction survey gear

Eska Remediation Design
Seismic Refraction survey



Geophones planted

Shot data collected

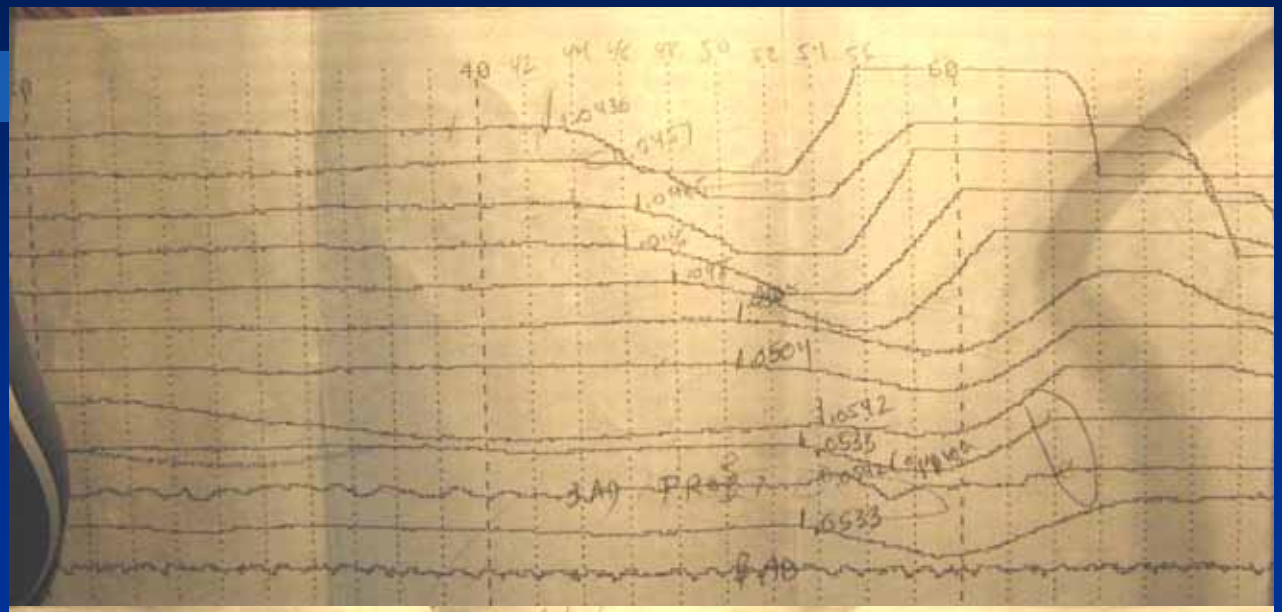
Eska Remediation Design
Seismic Refraction survey

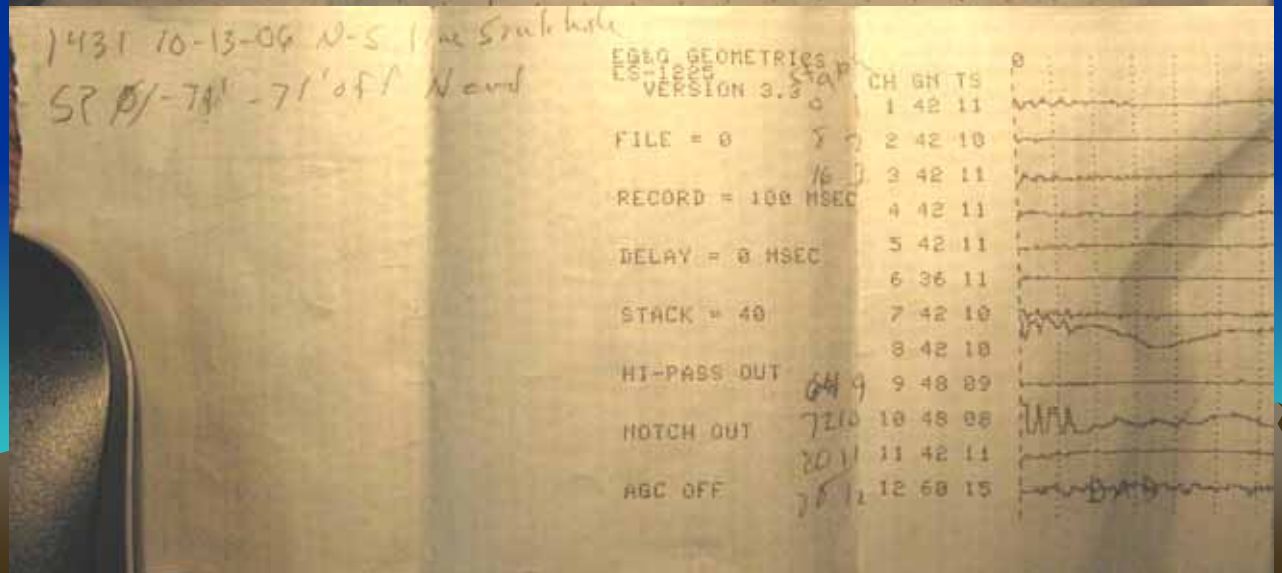
Data collected in seismograph, stacking multiple shots

Channels frozen as data collected

Geophone traces optimized to show 1st arrivals for printout

Eska Remediation Design
Seismic Refraction survey





Optimized geophone traces printed out.

First-arrivals times circled on the printout, with aid of seismograph screen cursor

More precise times picked later during office analysis

Printout header shows acquisition parameters — Channel, trace size, gain, record length, delay, filters on/off, # shots stacked

Eska Remediation Design Seismic Refraction survey

Geophone and shotpoint GPS located as Terrasync points

Shot point, geophone, and feature elevations level surveyed, benchmarked off geophone location

Eska Remediation Design
Seismic Refraction survey analysis

- Geophone and shotpoint elevations calculated in Excel, benchmarked off a GPS elevation at each site
- Point surface elevations used to construct local site topo contours in CAD.

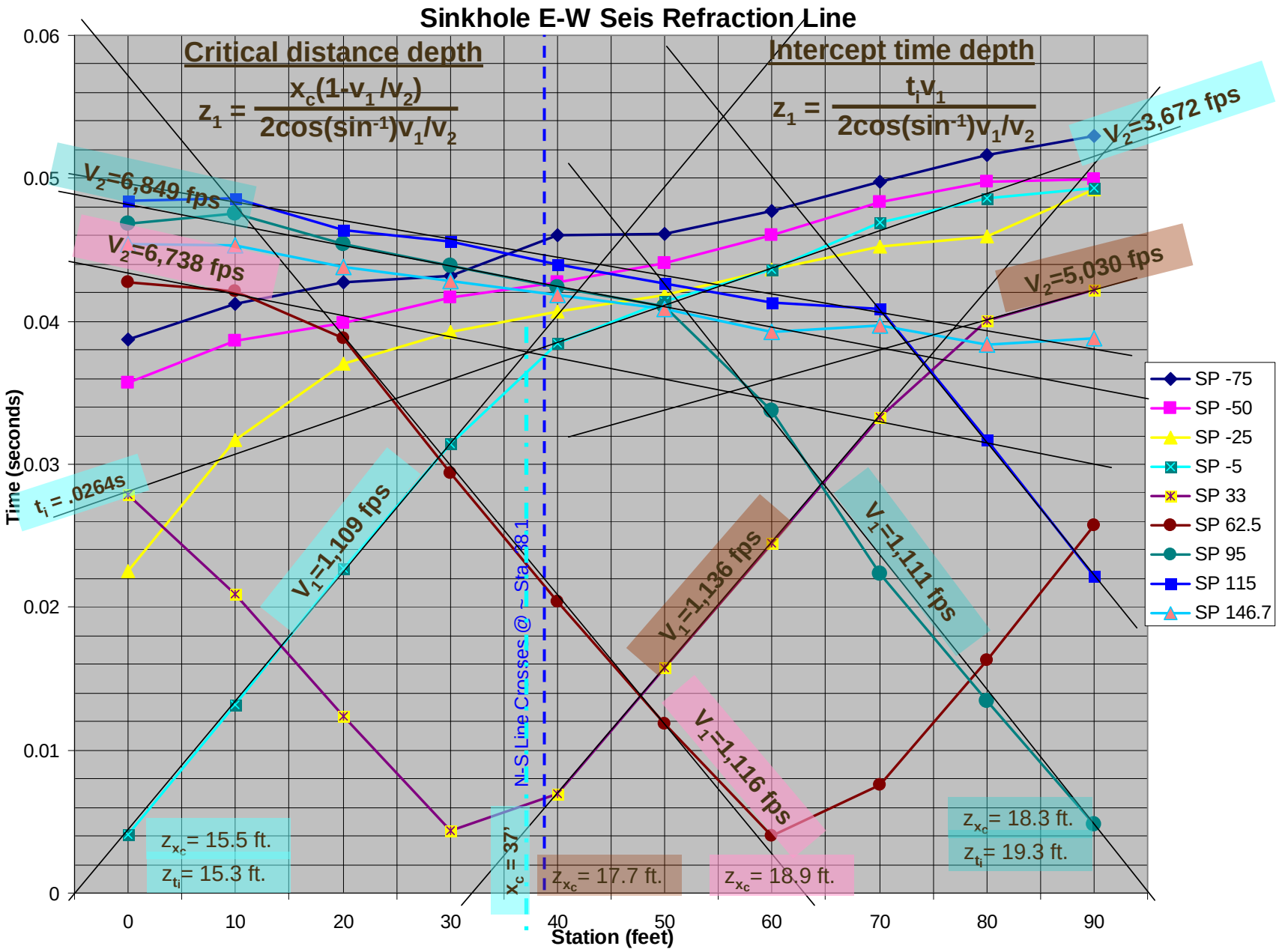
Eska Remediation Design

Seismic Refraction survey analysis

Printer tape arrival times and geophone distances put into Excel.

- Time-distance graphs plotted
- Refractor layers picked
- apparent velocities determined
- Ballpark depths calculated using critical time and distance-intercept formulas

Seismic Refraction Excel analysis



Eska Remediation Design

SIPT Seismic Refraction survey analysis

SIPT program used to calculate interface depths beneath each phone

- Routine calculates delay-time depths
- then runs inverse ray-trace iterations
  - calculates and adjusts interfaces where raypaths emerge enroute to each geophone

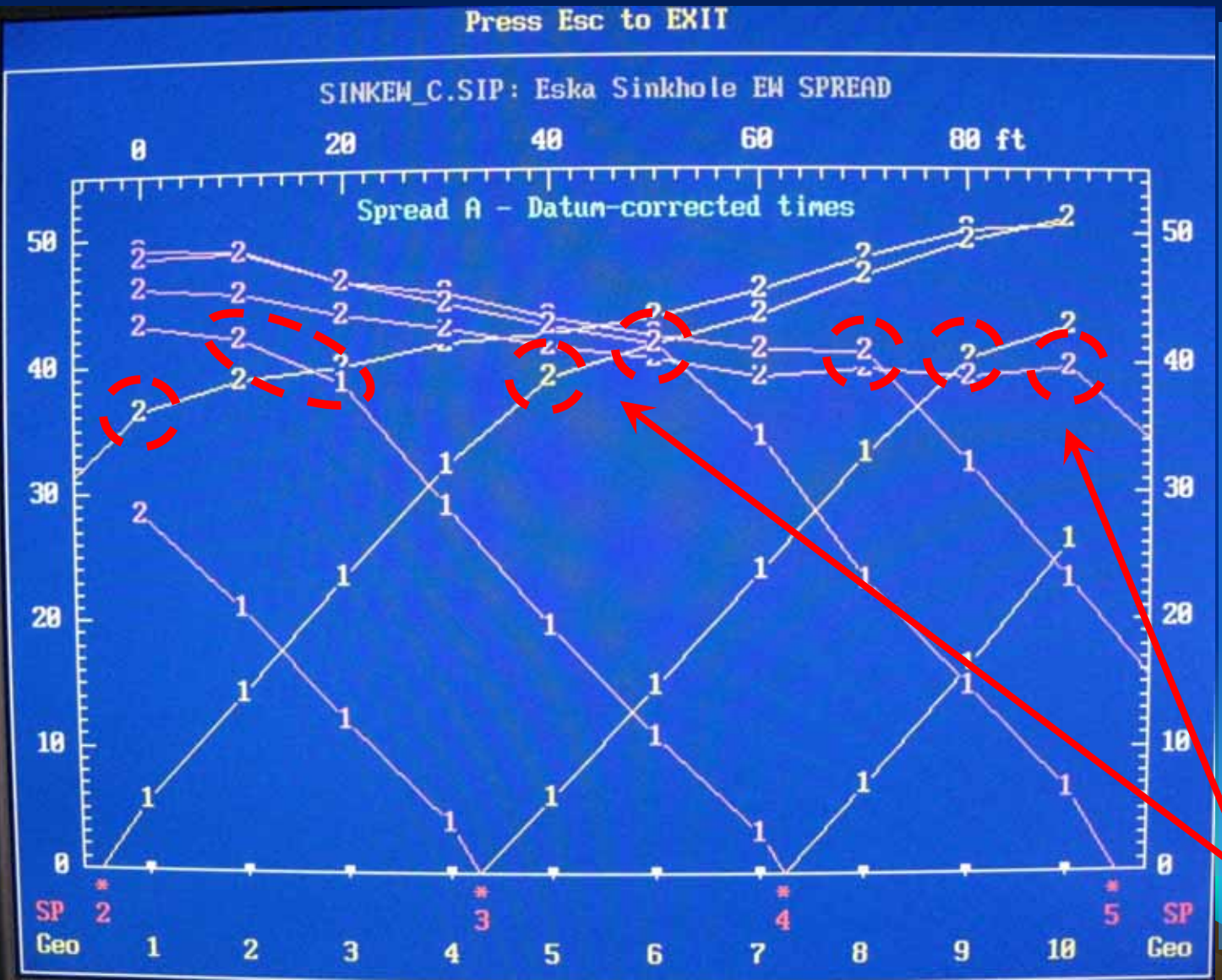
Eska Remediation Design

SIPT Seismic Refraction survey analysis

- First-arrival time input
- Time-distance graphs displayed
- Refractor arrivals picked
- Analyses run until solutions converged

Eska Remediation Design

SIPT Seismic Refraction analysis



SIPT program displays datum-corrected arrivals

Aids picking correct layers for each geophone from screen display

Also aided by velocity tables, depth tables, and depth plot

Solutions are iterated until convergence on satisfactory model

Critical factor making correct layer assignments near the critical distance

Eska Remediation Design

SIPT Seismic Refraction analysis

Refractor depths beneath each shotpoint

2	31.0	1035.6	16.8	1018.8
3	33.0	1035.7	19.3	1016.4
4	62.5	1035.0	21.4	1013.6
5	95.0	1032.7	21.1	1011.6

SIPT velocity tables, showing calculated weighted-average layer velocities– L_1 and L_2

SIPT depth table, showing refractor depths beneath each shotpoint and geophone

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev
1	0.0	1035.6	17.4	1018.2
2	10.0	1035.8	18.8	1017.0
3	20.0	1035.9	19.3	1016.6
4	30.0	1035.8	19.1	1016.7
5	40.0	1035.9	20.2	1015.7
6	50.0	1035.7	20.9	1014.8
7	60.0	1035.2	21.3	1013.9
8	70.0	1034.7	22.0	1012.7
9	80.0	1033.8	21.9	1011.9
10	90.0	1033.0	21.3	1011.7

Velocities used to formulate the Depth Mod

Refractor depths beneath each geophone

4	3	42.7	1180	
4	4	32.8	1114	
4	5	22.9	1121	
4	6	13.1	1114	
4	7	4.7	1180	
4	8	8.5	1119	
4	9	18.0	1184	
4	10	27.9	1004	
				1122
5	7	35.1	1041	
5	8	25.1	1125	
5	9	15.0	1122	
5	10	5.0	1044	
				1117
6	9	35.0	1105	
6	10	25.0	1127	
				1083
				1116

ocity computed for Layer 1 = 1117

Layer 1 calculated velocity

VELOCITY ANALYSIS TABLES for SINKEN_C.SIP

Avg = 6541 for 4 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread A SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err Err	Geo	Err	Geo	Err	Geo	Err	Geo
1 4	1 2	5786	-4.8	0.000	-0.000	1	0.000	2				
1 5	1 6	6866	-4.8	0.276	-0.403	2	0.394	4	0.229	1	-0.129	6
1 6	1 8	6975	-3.3	0.198	0.400	3	-0.234	2	-0.198	6	0.134	4
1 7	1 10	8161	3.1	0.007	-1.920	10	0.997	7	0.817	9	-0.785	1
2 5	5 6	4998	-1.9	0.000	0.000	5	0.000	6				
2 6	5 8	5604	0.0	0.206	0.261	6	-0.221	5	-0.181	8	0.141	7
2 7	5 10	6004	6.6	0.719	-1.129	10	0.060	9	0.747	7	-0.675	5
3 7	9 10	11600	3.5	0.000	0.000	10	-0.000	9				

Avg = 7186 for 40 Pts

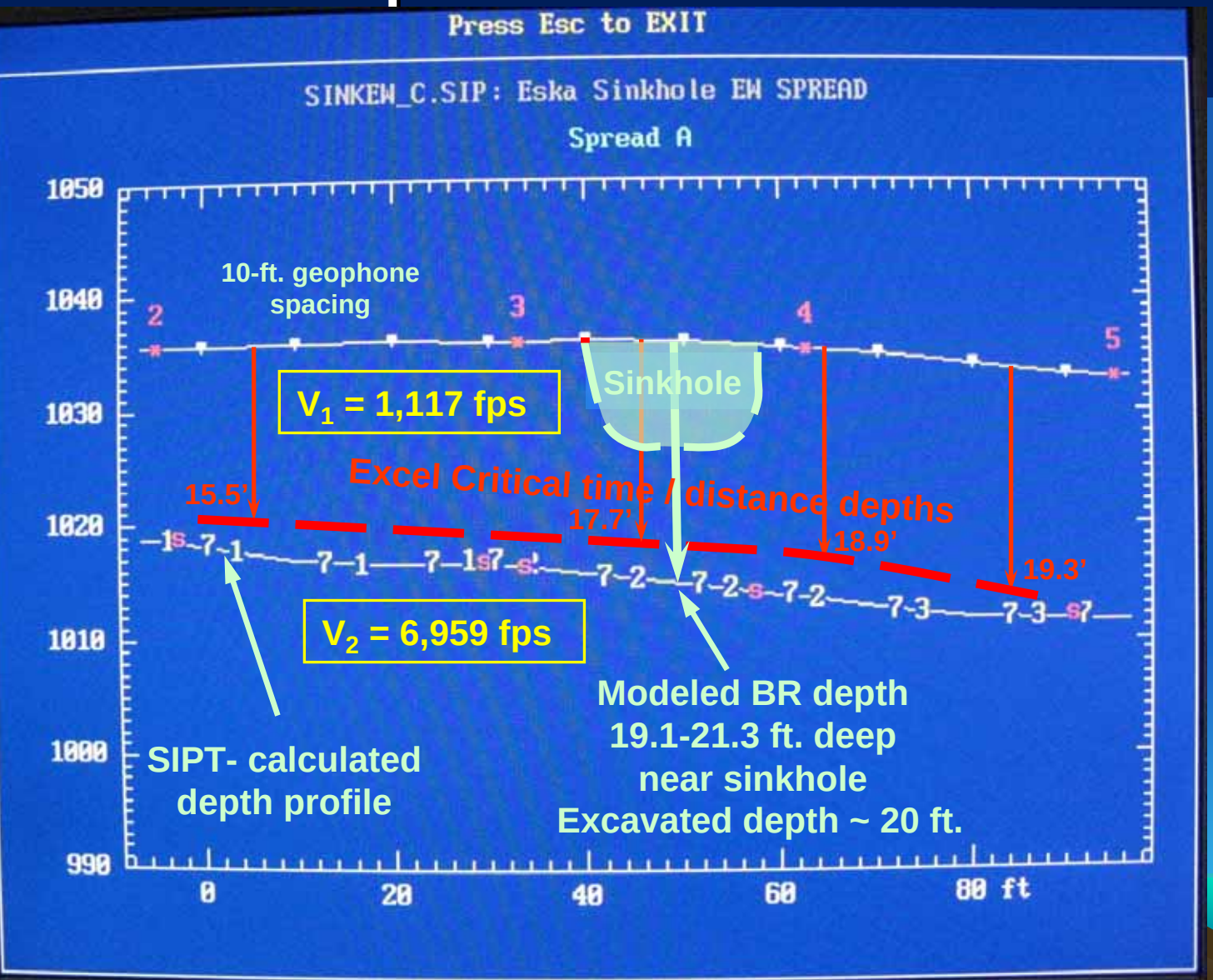
Wtd Avg Velocity computed for Layer 2 = 6959

Layer 2 calculated velocity

Use ↑↓ arrows, Home/End, PgUp/Dn keys to scroll table. Press Esc when finished.

Eska Remediation Design

SIPT Depth Plot – E-W Sinkhole Line

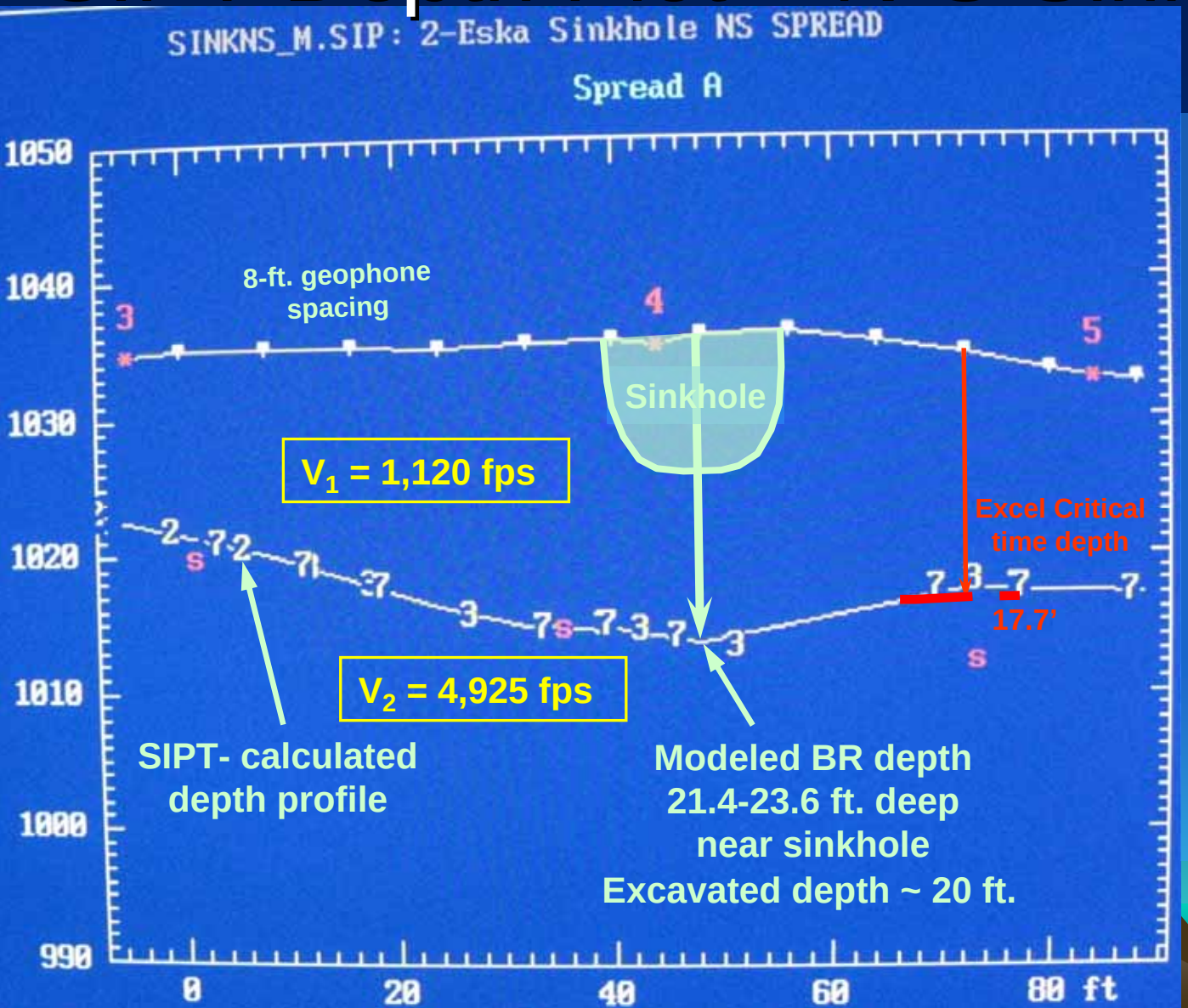


SIPT Depth Plot

- Geophone locations correlated with surface features to gauge BR depth beneath features of interest
- Refractor depth models generally solve within 5% of actual interface depths
- Two-layer solutions generally resolve better than three-layer models.

Eska Remediation Design

SIPT Depth Plot – N-S Sinkhole Line



SIPT Depth Plot

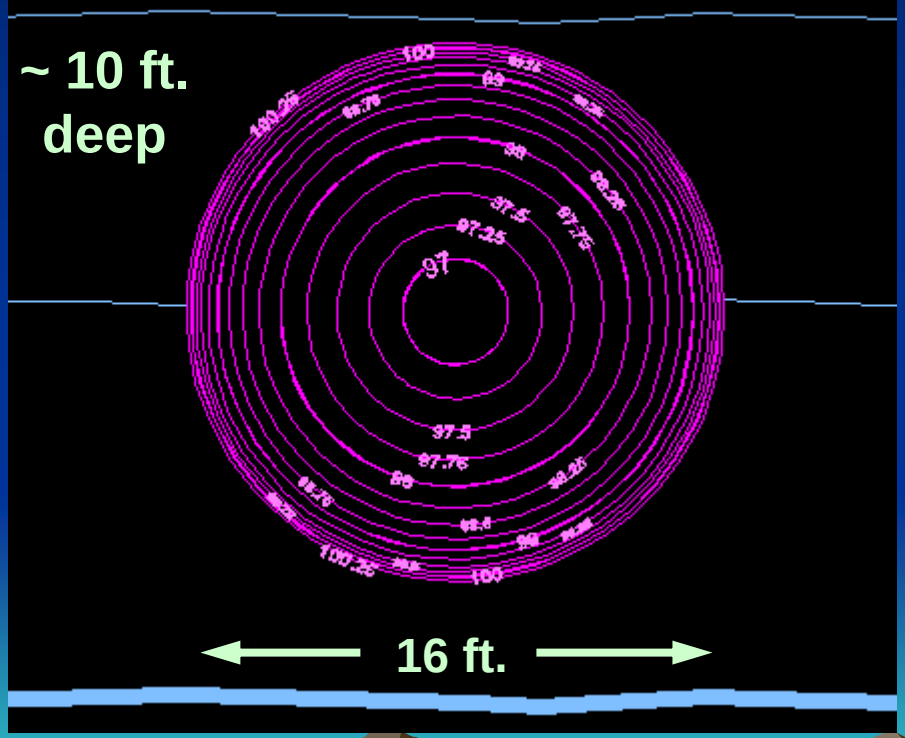
- Modeled bedrock depths beneath sinkhole similar to E-W line solution.
- Lower average bedrock acoustic velocities probably due lateral velocity variations, or discontinuous weathered zones.
- Two-layer solution showed better resolution than the 3-layer model.

Eska Remediation Design

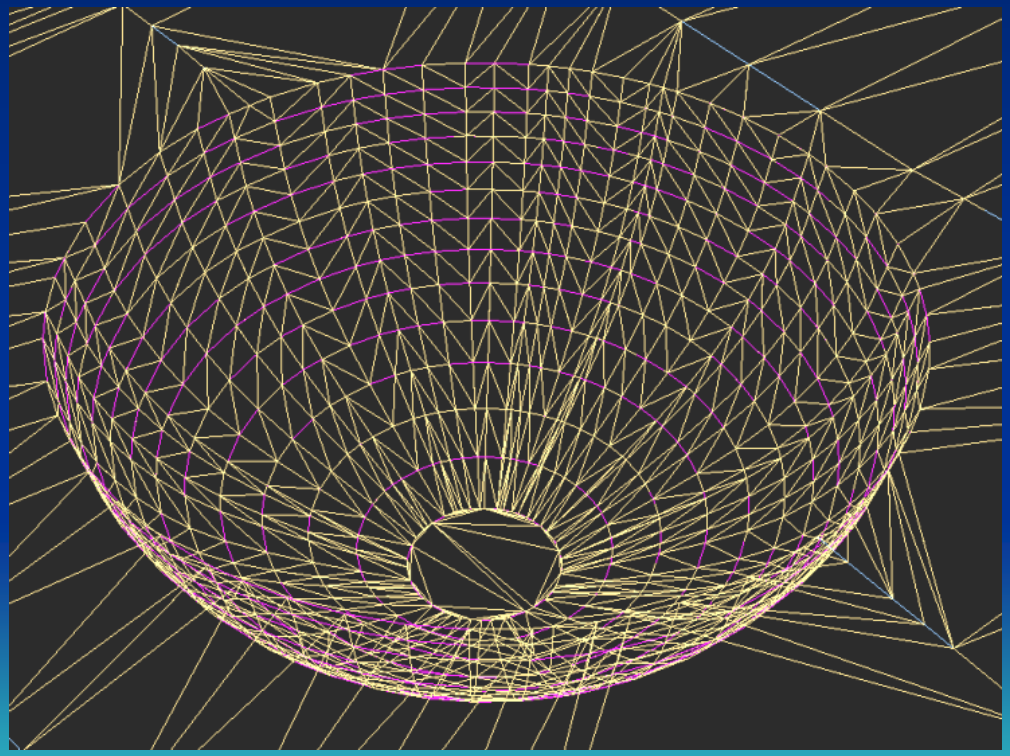
Sinkhole CAD model for volumes

Approximate OG dimensions and topography

Sinkhole OG



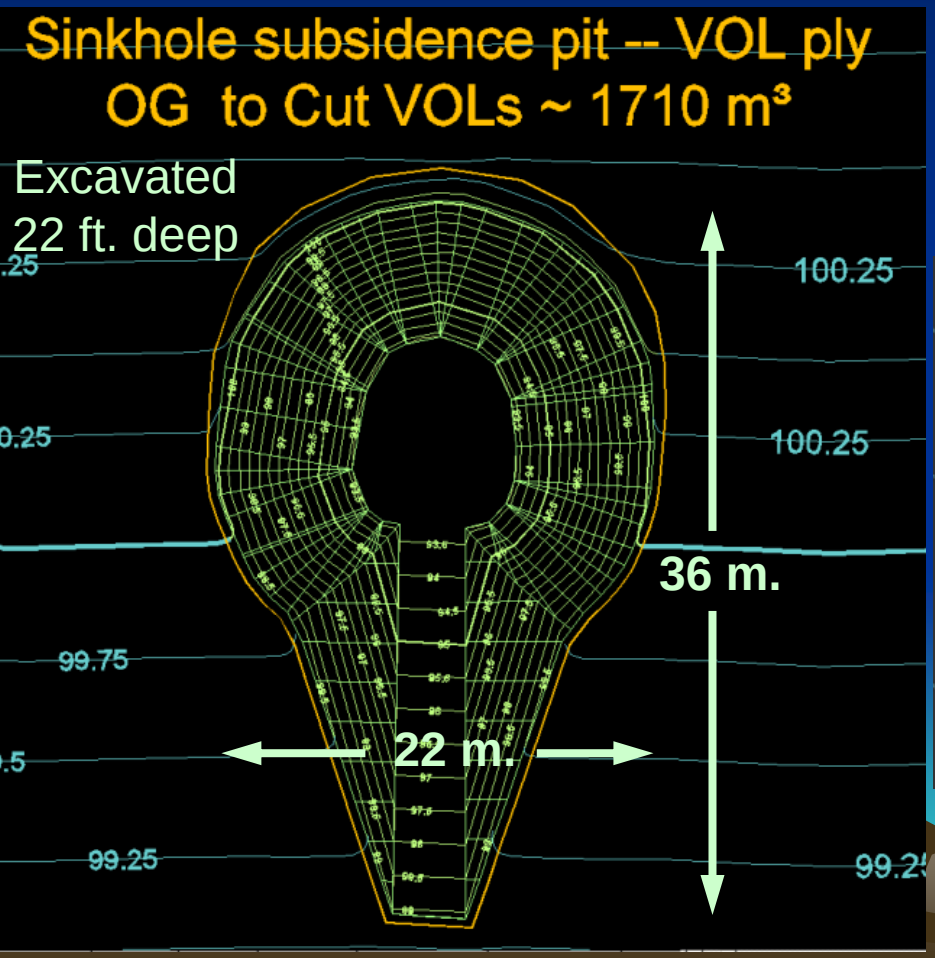
Sinkhole OG – oblique 3D



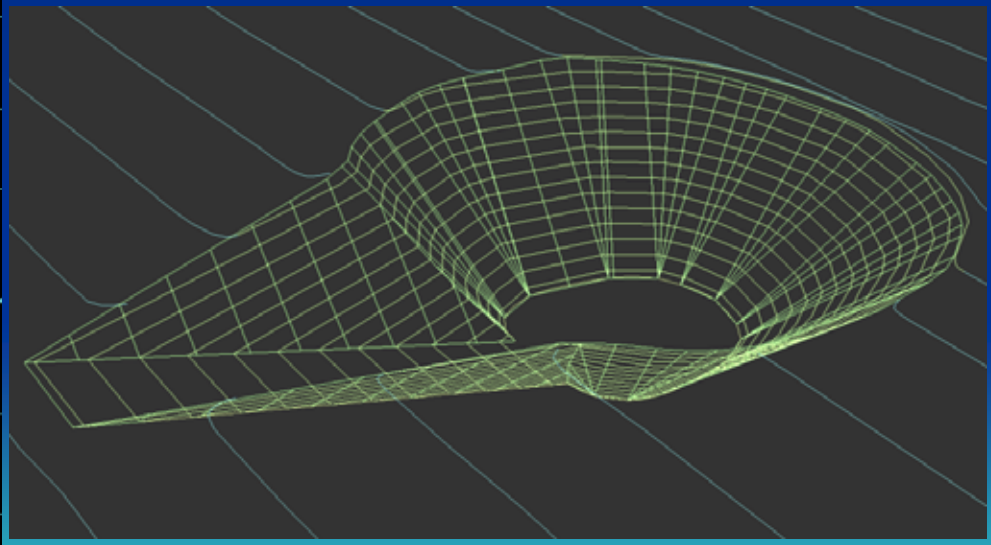
Eska Remediation Design

Sinkhole CAD model for volumes

Excavation dimensions and volumes based on SIPT seismic depth models



Sinkhole Excavation model -- oblique 3D

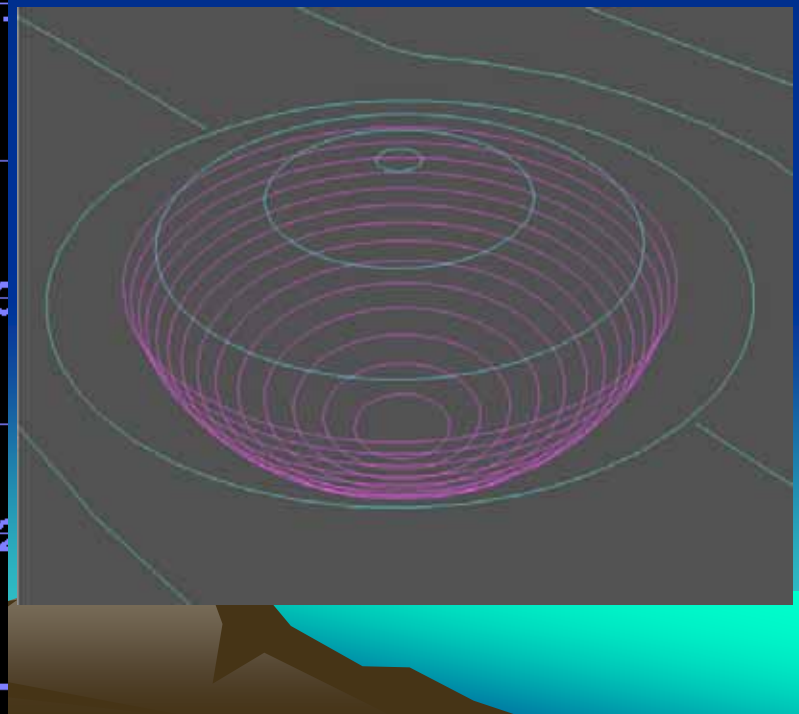


Eska Remediation Design

Sinkhole CAD model for volumes

Excavation dimensions and volumes based on SIPT seismic depth models

Sinkhole Excavation vs. Fill 3D model --



PH II -- Sinkhole Remediation

Sinkhole excavation progresses

PH II -- Sinkhole Remediation

Excavation below BR at 20 ft., 5 ft. deep into shaft, exposes flowing water on floor

Timbers in bucket

More exhumed timbers

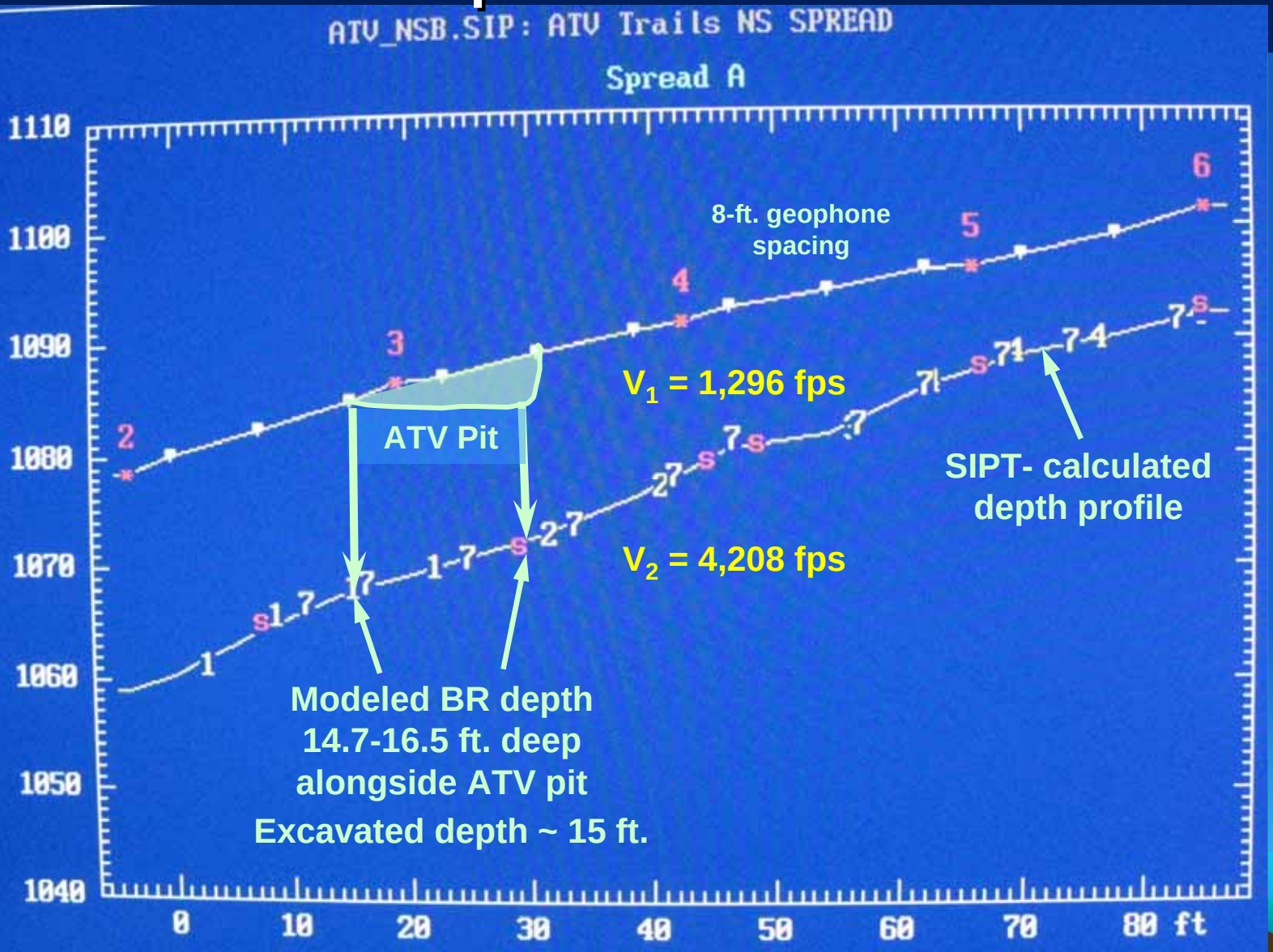
Boulder bottom fill

Emplacing large aggregate fill

9 ft. log ladder

Eska Remediation Design

SIPT Depth Plot – N-S ATV Line

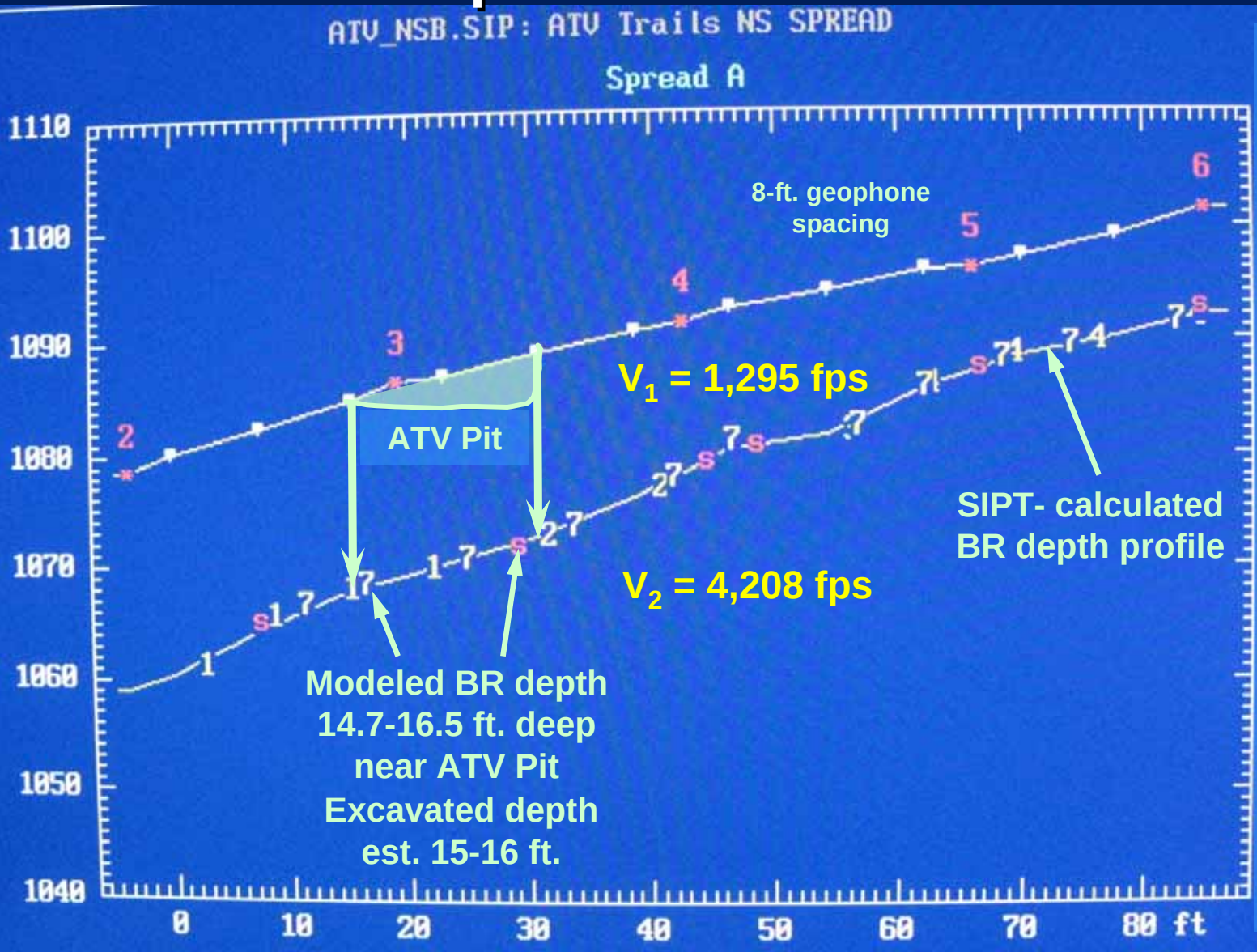


SIPT Depth Plot

- BR layer model does not see size & shape of openings
- No information about VO condition or depth into BR
- Question: how to determine proper size and type of equipment to clean out possible shafts?

Eska Remediation Design

SIPT Depth Plot – N-S ATV Line



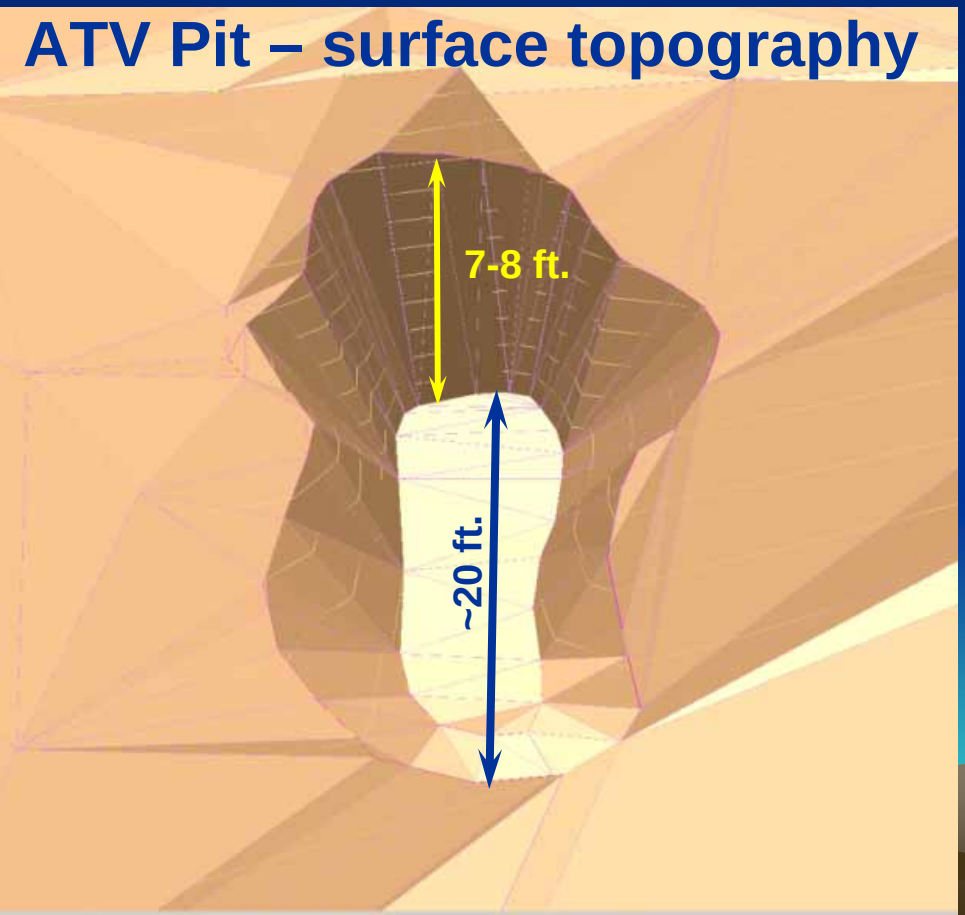
SIPT Depth Plot

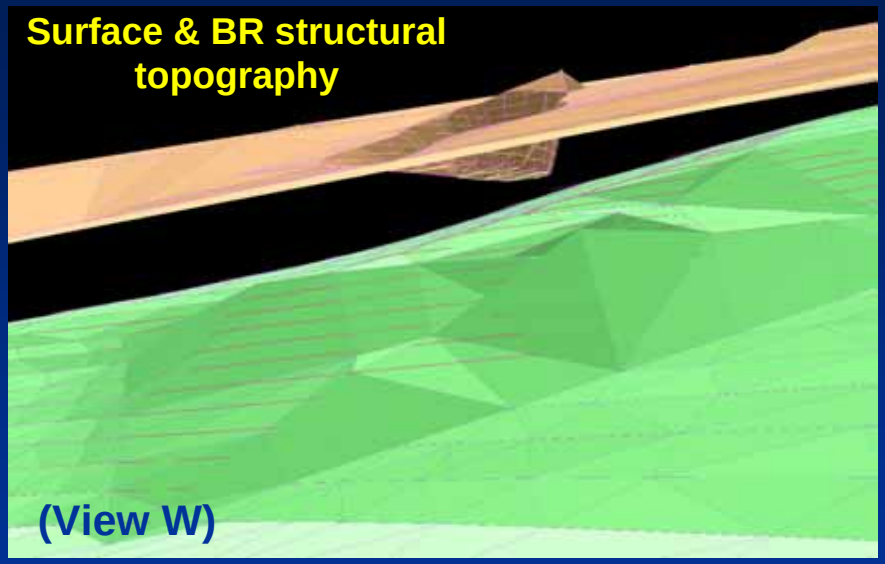
- Predicts bedrock depth
- Seismic refraction doesn't see shaft opening size or depth
- Uncertainty concerning existence, condition of opening, and type and size of equipment required for closure.

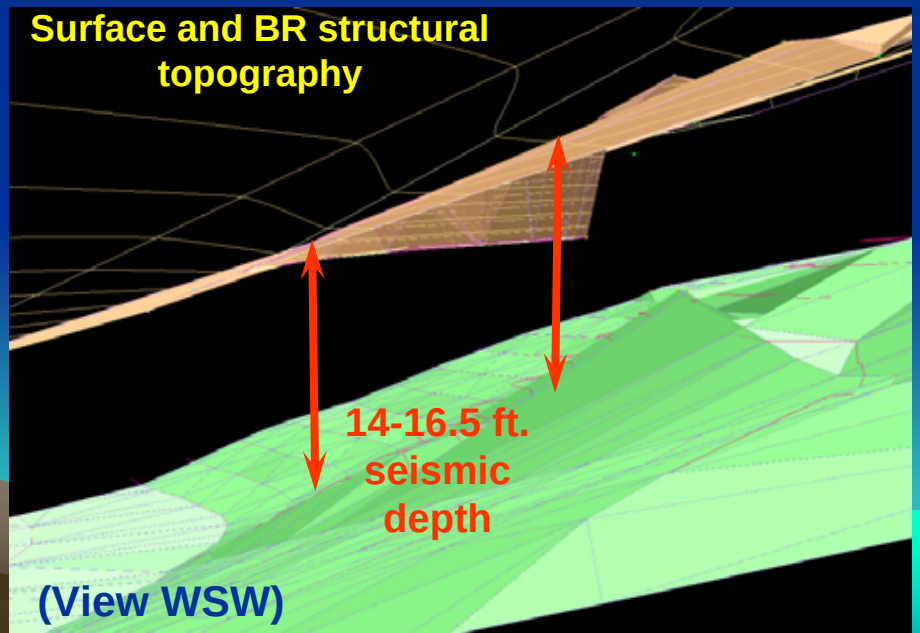
Eska Remediation Design

ATV Pit--3D models from seismic data

How to assess buried VO depth and condition? -- not evident from surface & BR models.







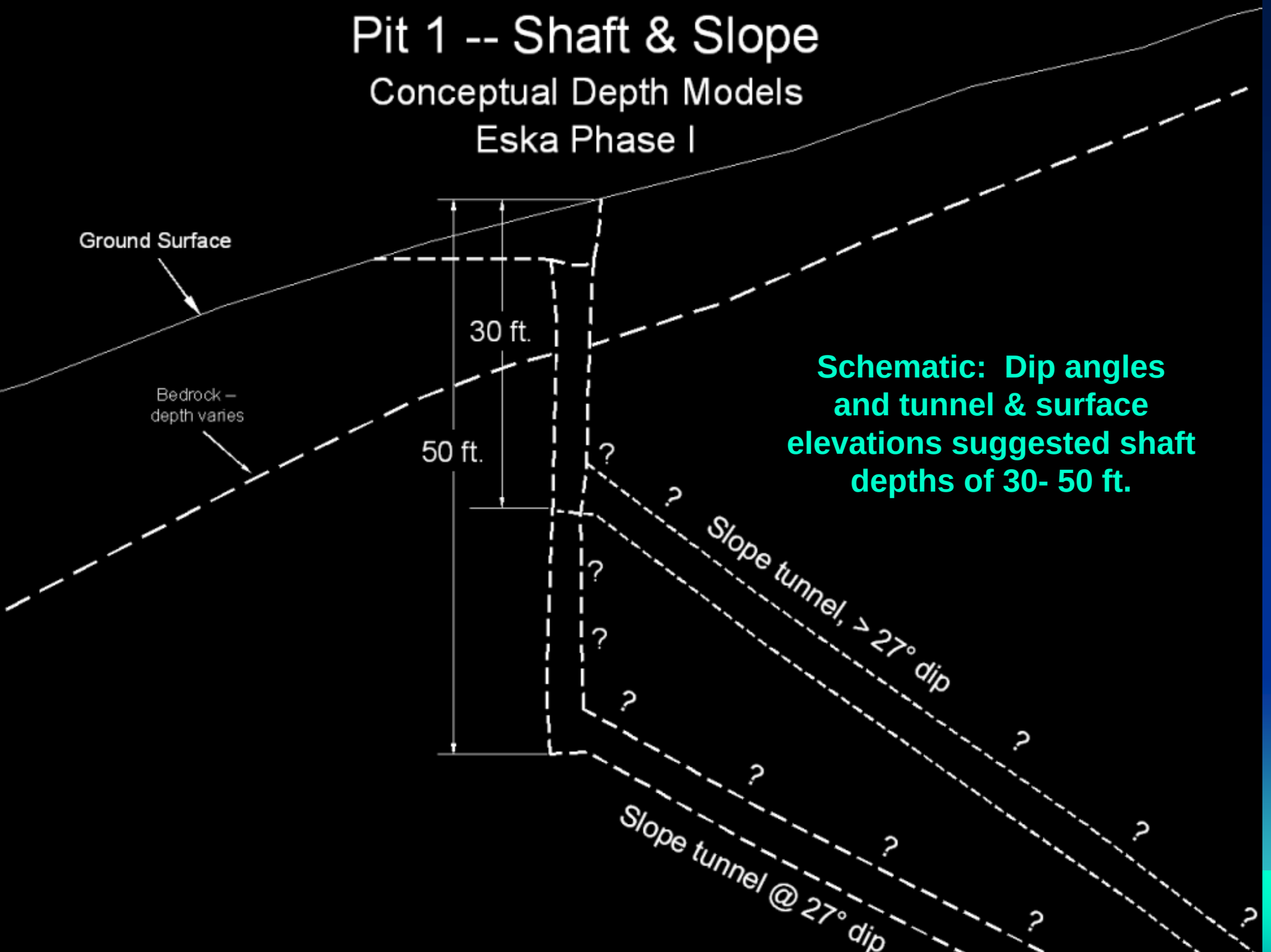
Eska Remediation Design

Eska historic mine data – georef. map

Pit 1 -- Shaft & Slope

Conceptual Depth Models

Eska Phase I



Schematic: Dip angles and tunnel & surface elevations suggested shaft depths of 30- 50 ft.

Eska Remediation Design

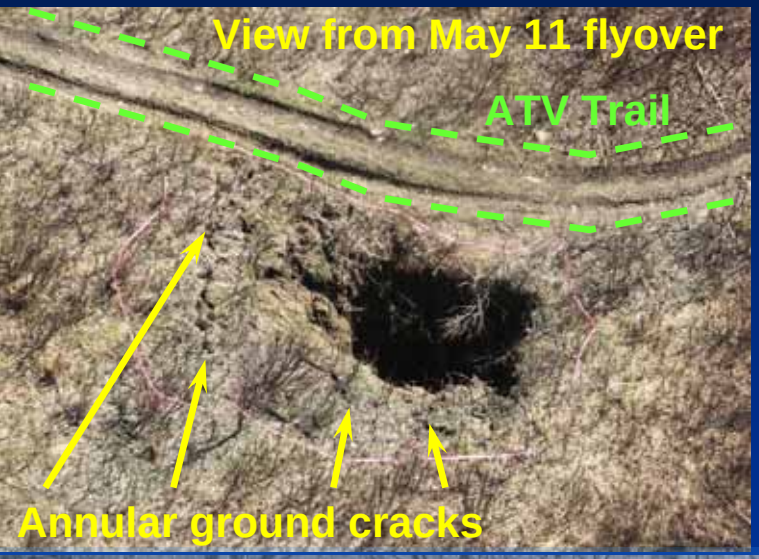
Eska 1993 VO closure data – photos.

Shafts open and raveling, 15-25 ft deep

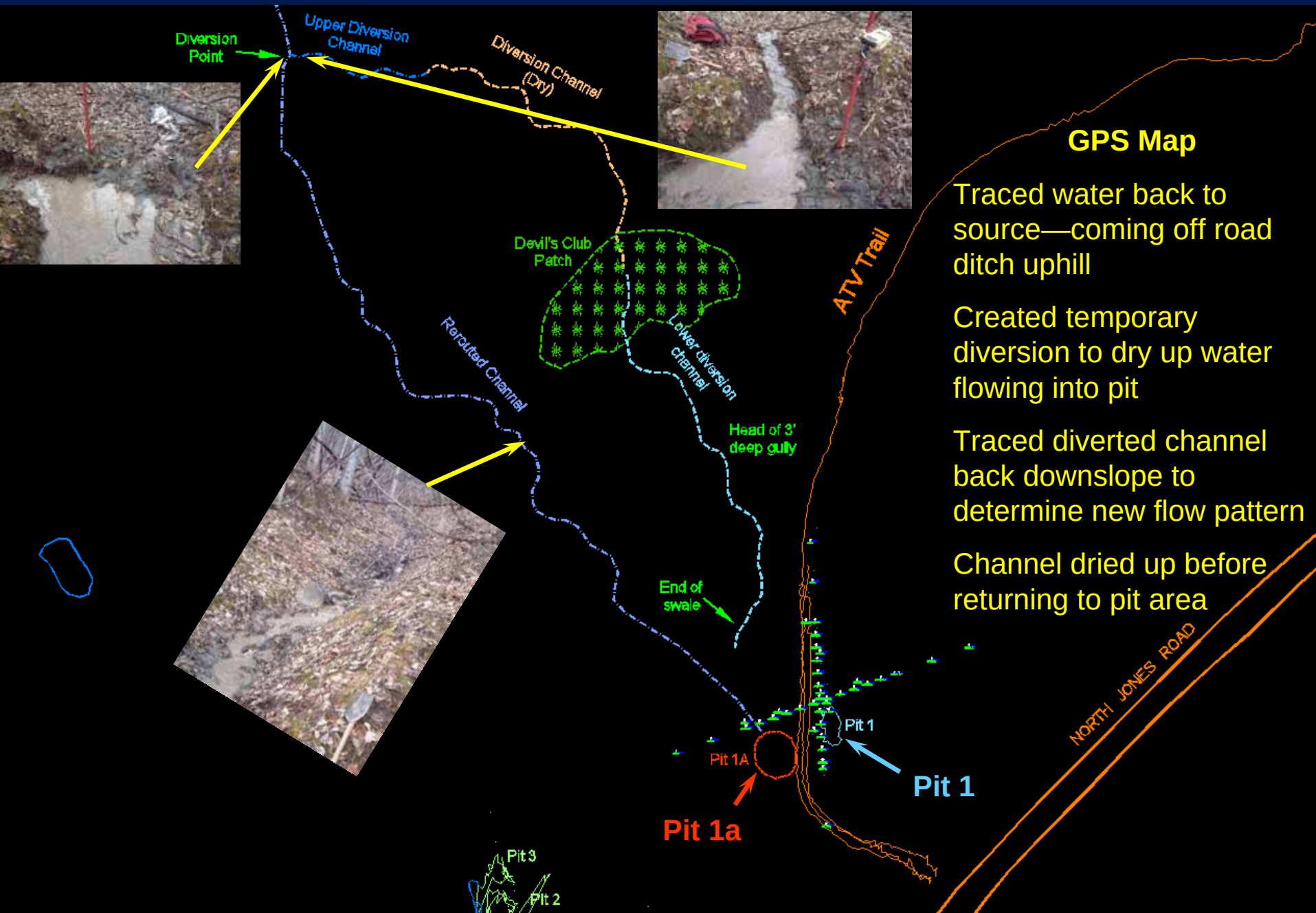
Remediated by removing overburden, filling w/ unclassified fill.

Eska Closure Emergency May 2007

A 2nd pit opens just west of pit 1– May 5 visit



Pit 1a Emergency – Temporary remediation



GPS Map

Traced water back to source—coming off road ditch uphill

Created temporary diversion to dry up water flowing into pit

Traced diverted channel back downslope to determine new flow pattern

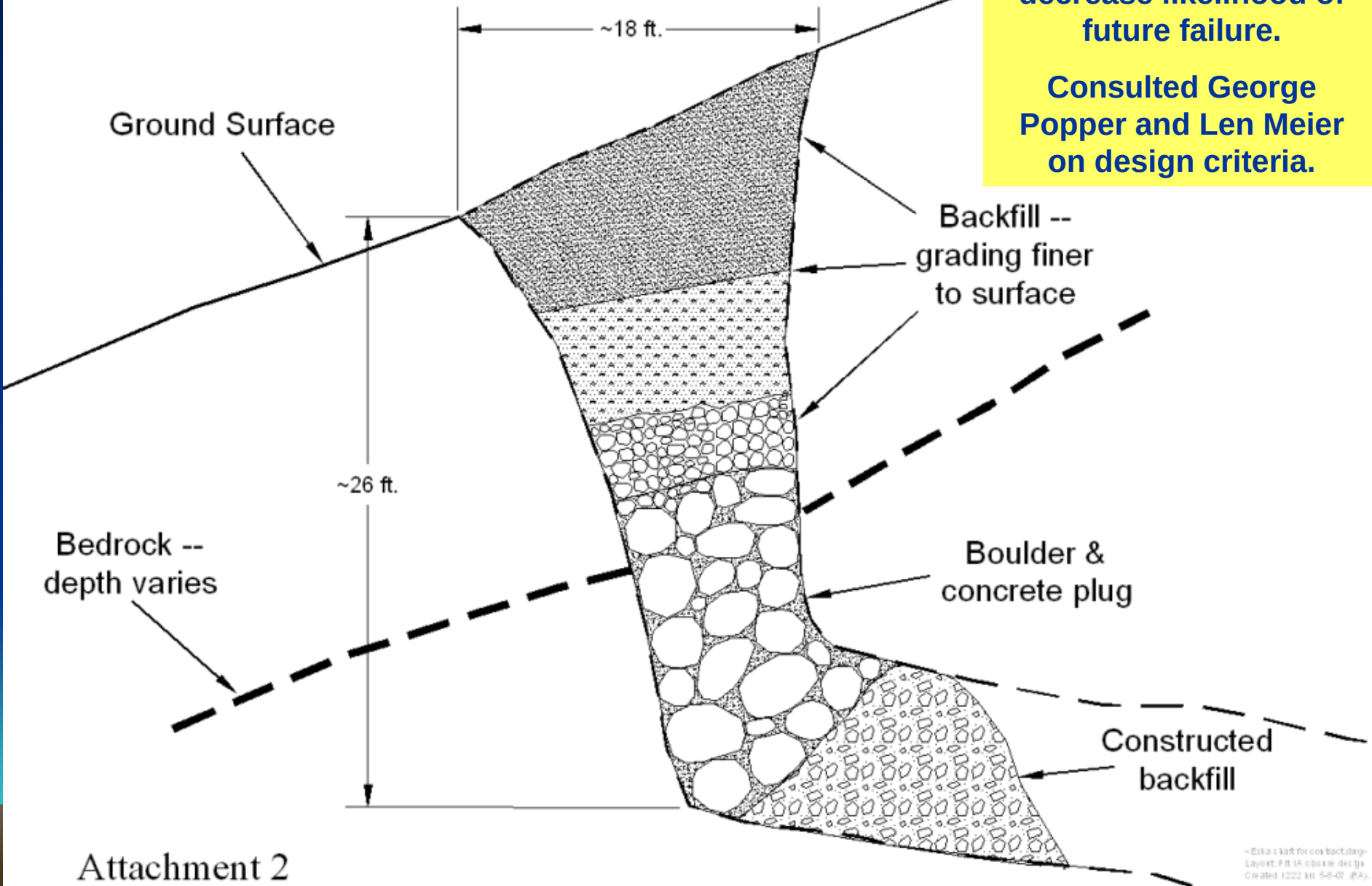
Channel dried up before returning to pit area

Pit 1a Closure Design

Eska Phase I

Our program decided to implement a more permanent closure to decrease likelihood of future failure.

Consulted George Popper and Len Meier on design criteria.



Attachment 2

Phase I Excavation -- Pits 1, 1a, 2 & 3

Access pushed in

Inspecting Pit 1a

Pit 1a bottom

Beam above adit opening, Pit 1a

Pit 1 — fill across adit

Nighttime inspector

Pit 3 opening collapse

Pit 2 piping feature

Phase I -- Pits 1 & 1a Remediation

New diversion ditch

Stockpile – boulders & large dimension fill

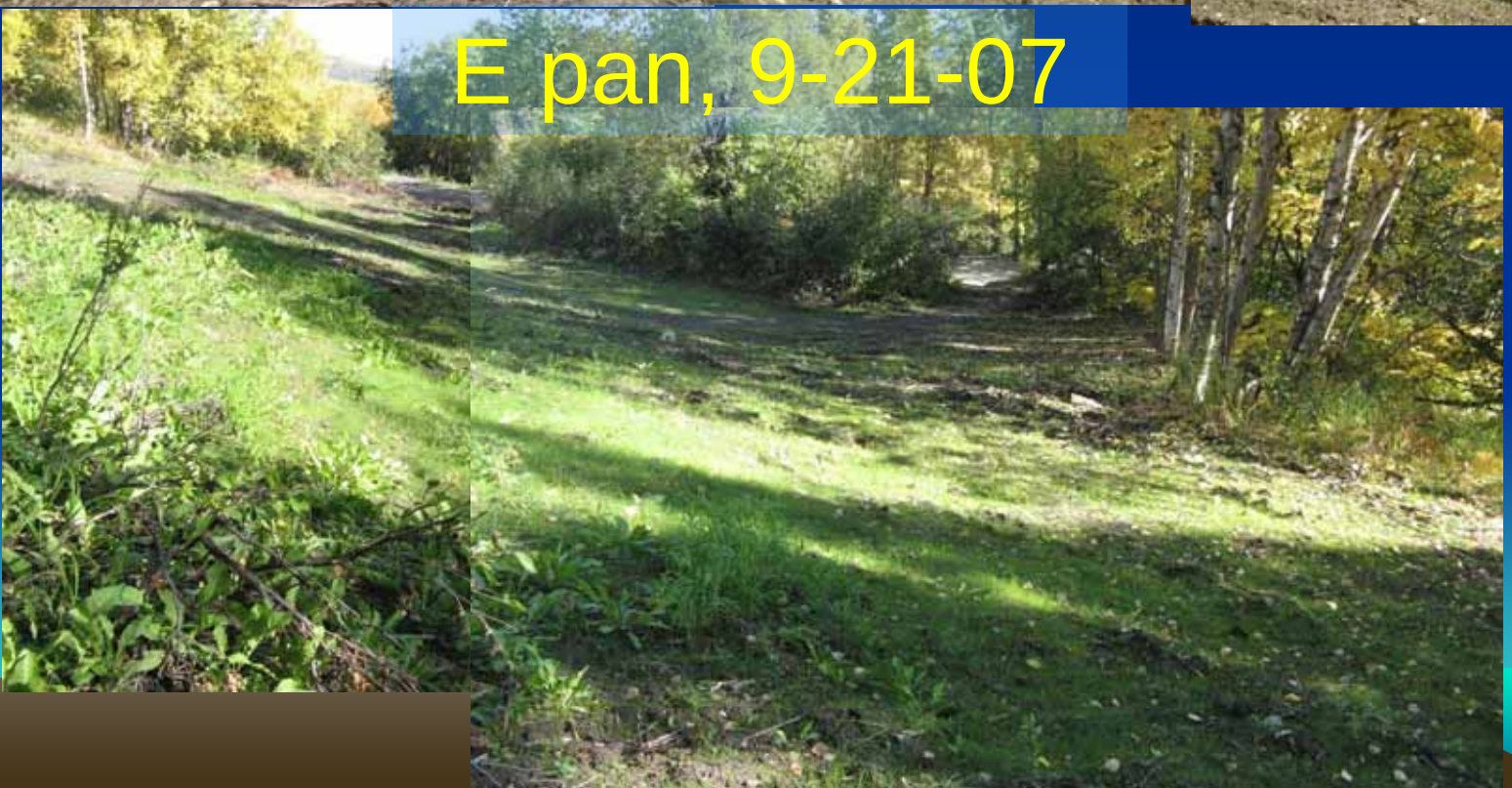
Inspecting Pit 1a

Constructing boulder & concrete plug

2nd course of boulders, concrete, & rebar

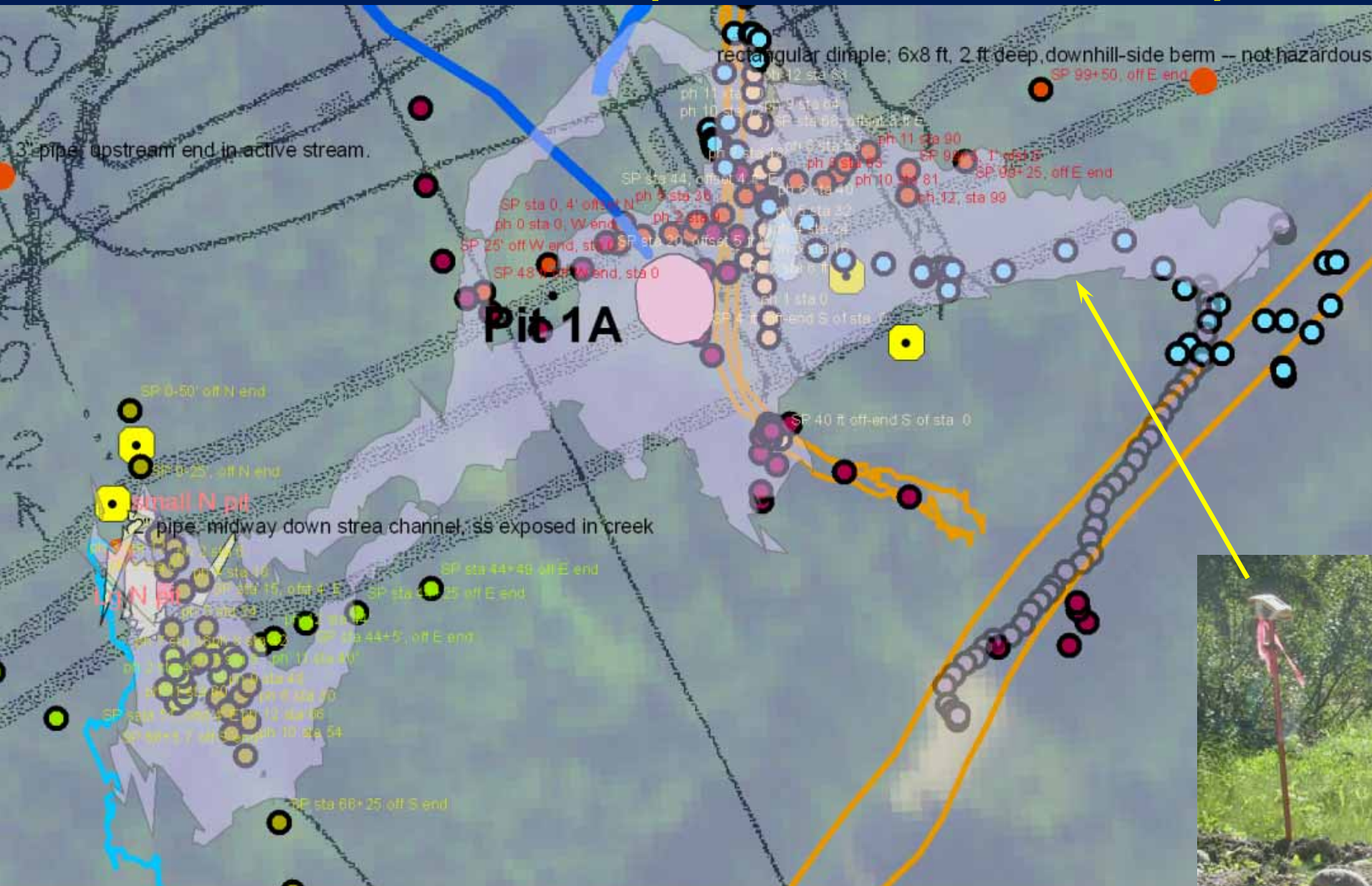
Large-dimension fill atop concrete plug

Phase I finished -- Pits 1 & 1a



GPS disturbed area perimeter

Phase I – Pit remediation disturbed Area
Documented for maps and closeout report



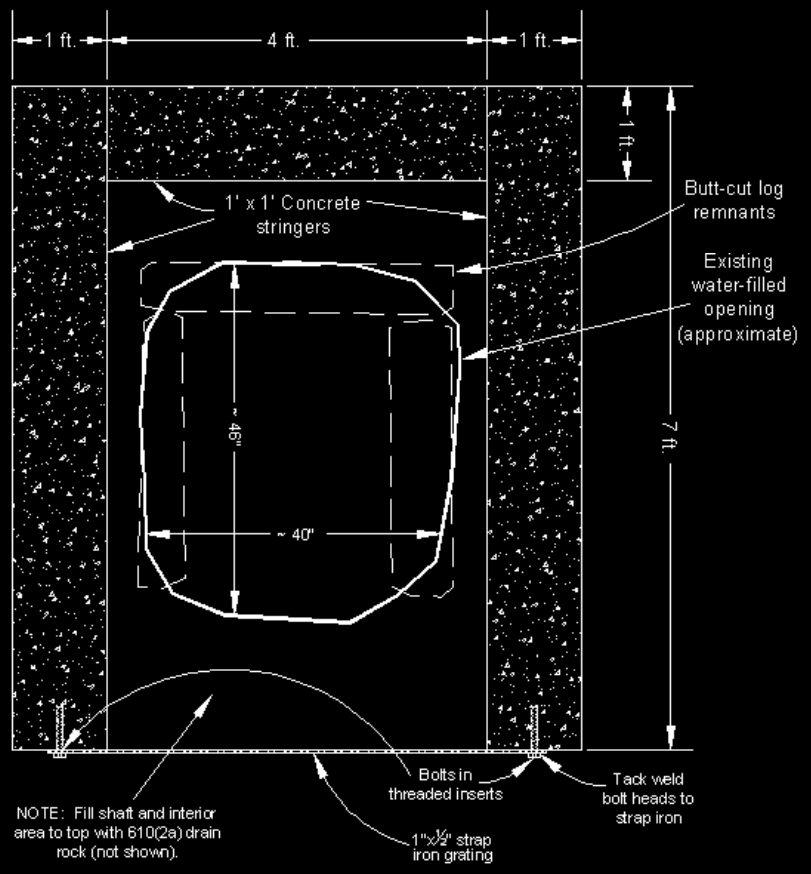
PH II – Conic Pit Remediation

Conic Pit & David Airshaft

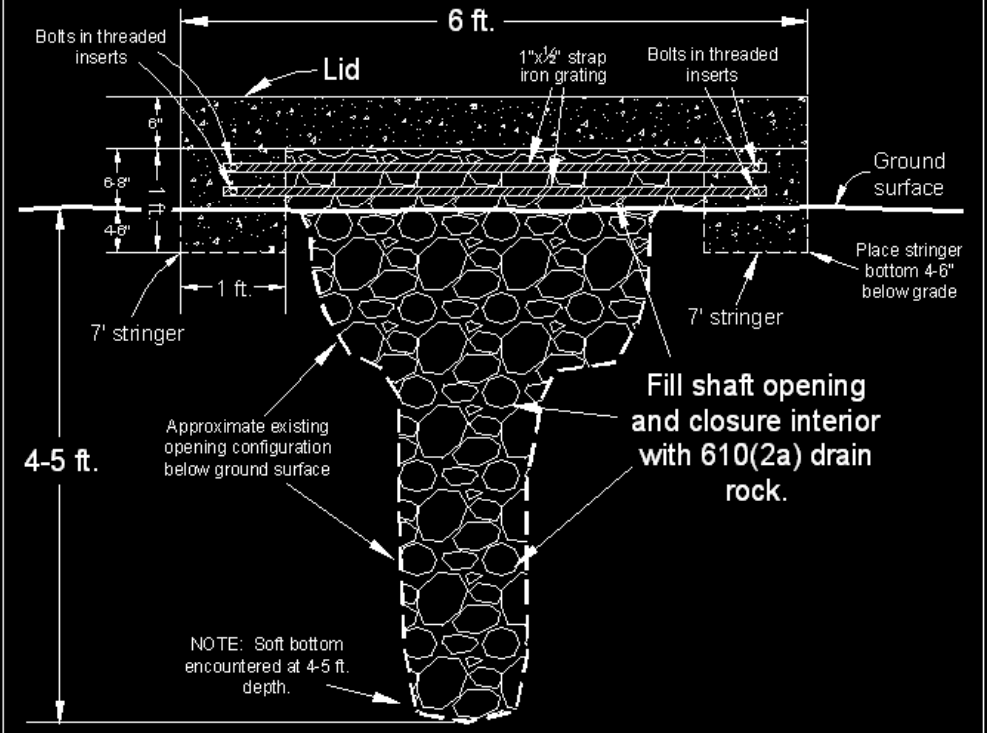
Water-Filled Shaft Closure Design

Eska Mine Closures, Phase II

Top View -- Without Lid



Front View -- with Lid

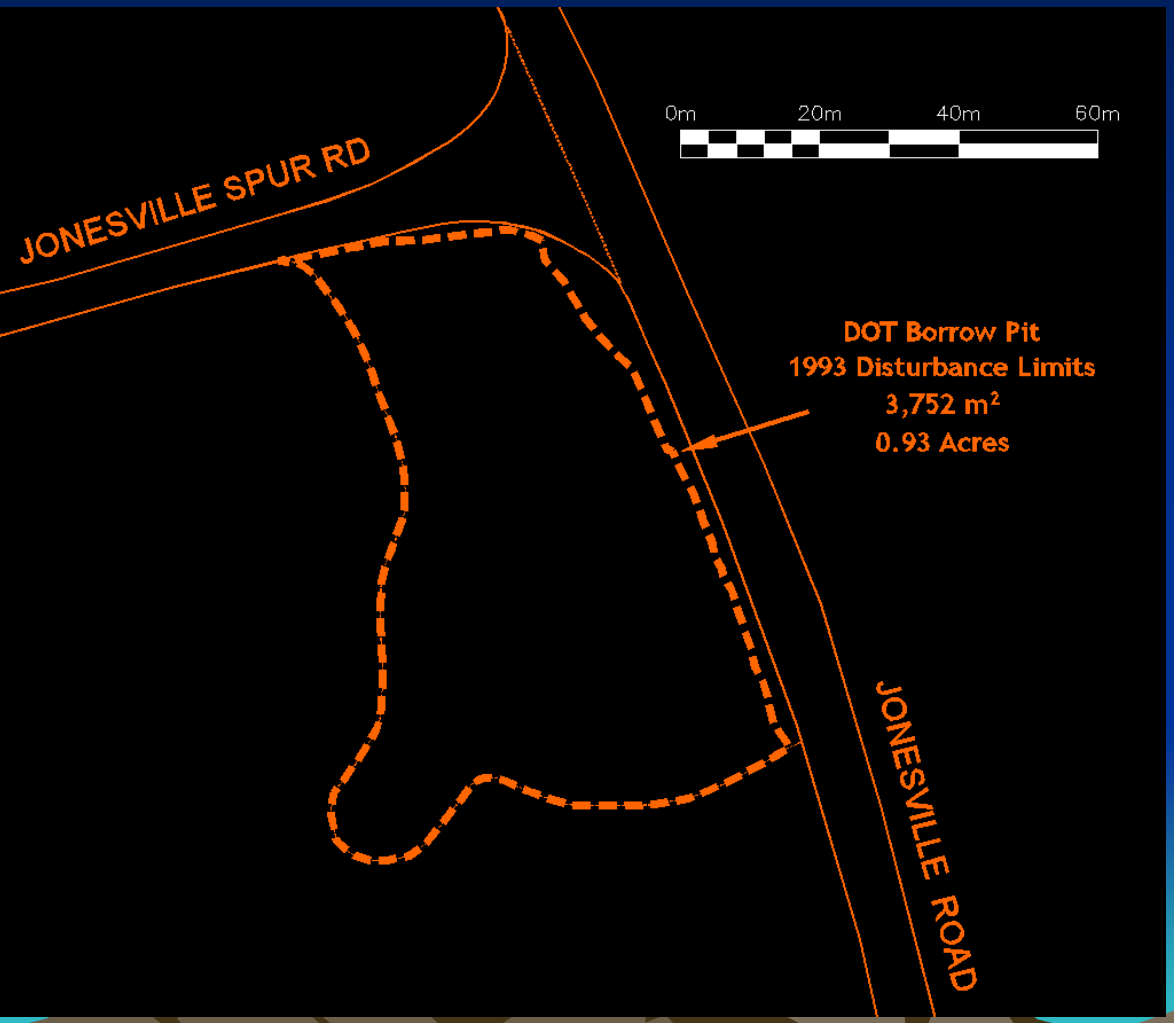


<Eska_1a_water_filled_shafts_for_contract.dwg>
Layout: Water shaft closure design
Created 1527 hrs 9-5-07 (RA).

Water-filled Shaft Closure As-built

FINIS

Gravel Extraction Area Measurement & Permit reconstruction



Dated disturbance limits interpreted on 1993 aerial mapping

Area excavated for borrow through 2003 for several projects – much enlarged

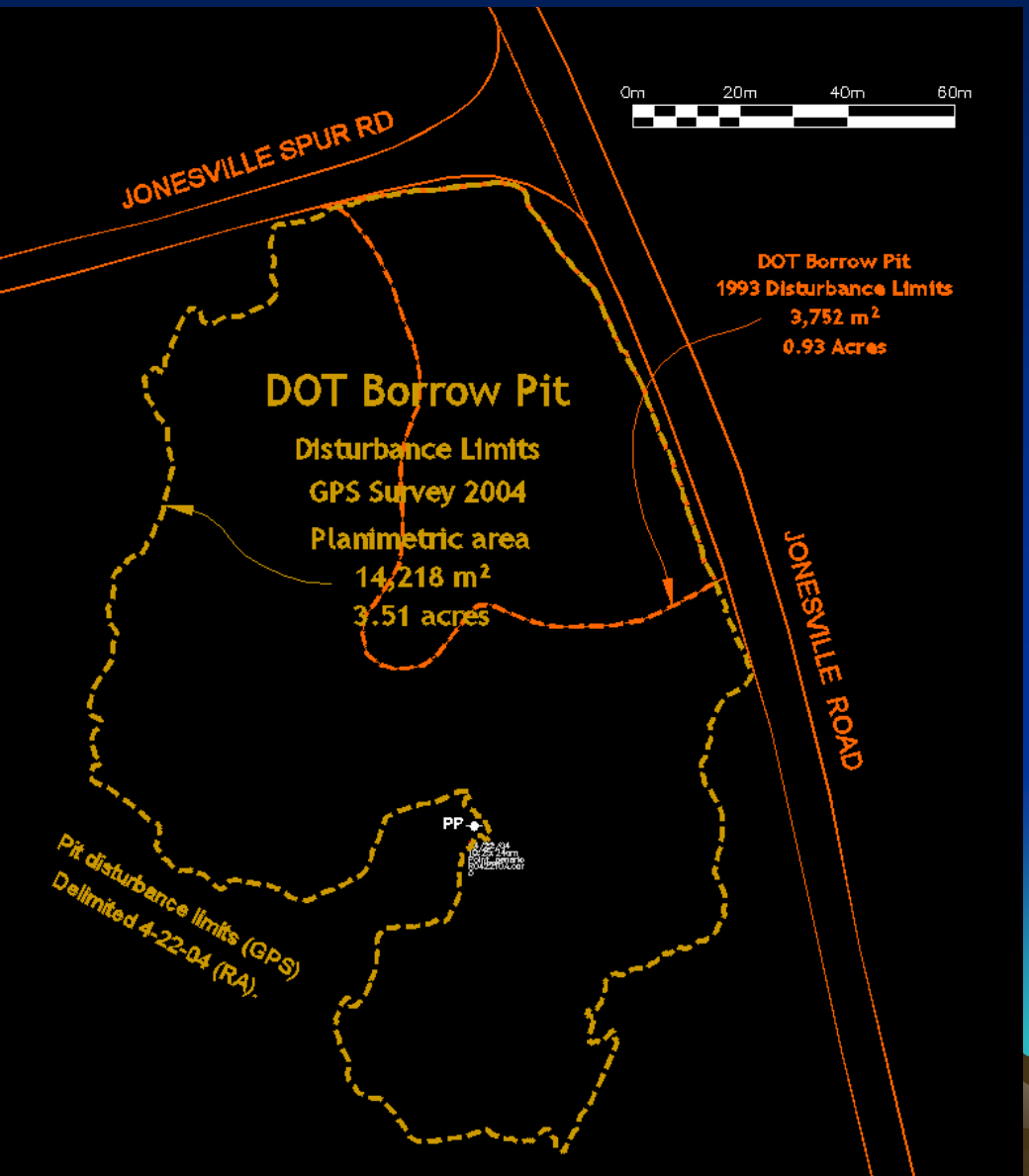
No boundaries or topography surveyed since 1993

Gravel Extraction Area Measurement & Permit reconstruction

GPS survey of disturbance boundaries in April 2004

Survey lines displayed atop 2005 USDA imagery

Gravel Extraction -- 2004 Measurement of Enlarged Area



Disturbance boundaries GPS surveyed in April 2004

Significant excavation enlargement of >3.5X

Question: how much extractable gravel remained in permit area?

Sufficient quantities to supply 2005 AML spoils fire reclamation project?

Enlargement Raises Boundary Issues GPS collection of existing features

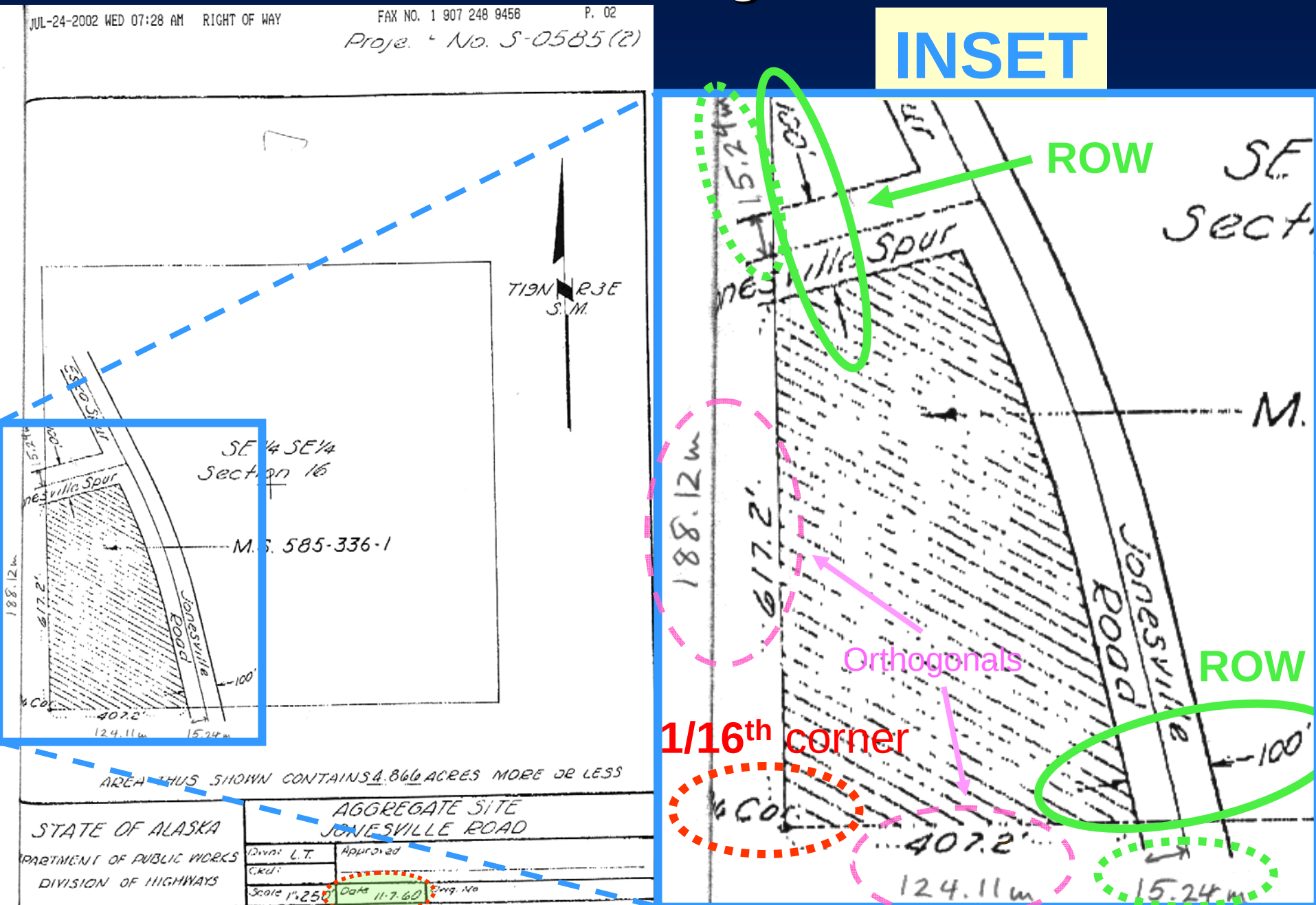
Question: where are the permit boundaries?

Collected GPS road CL and ditch/edge alignments

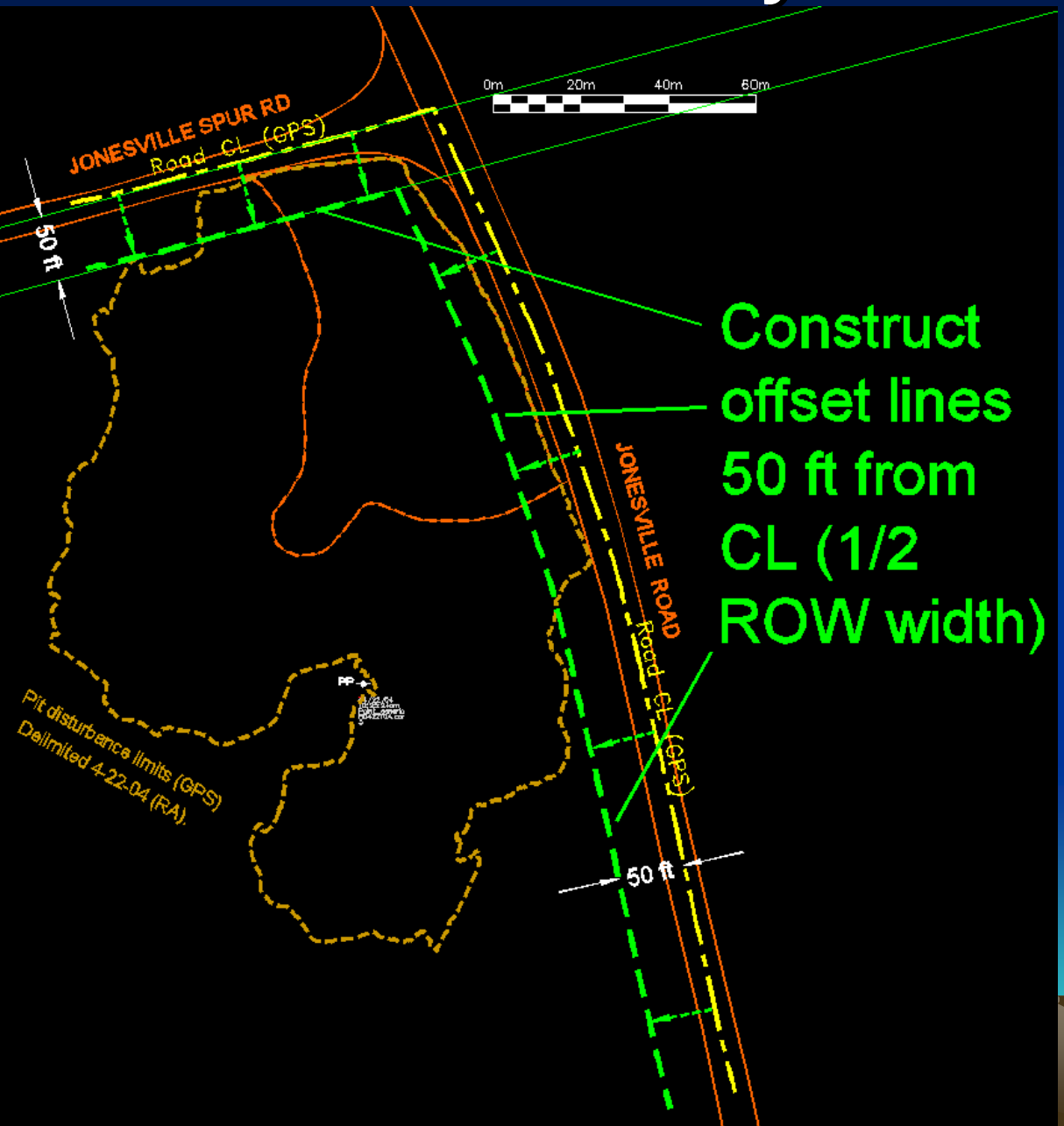
Always a good idea to collect utility and structure GPS location data when in the field

May prove useful when compared with plat, engineering plans, or geographic data

Permit found -- drawing with dimensions

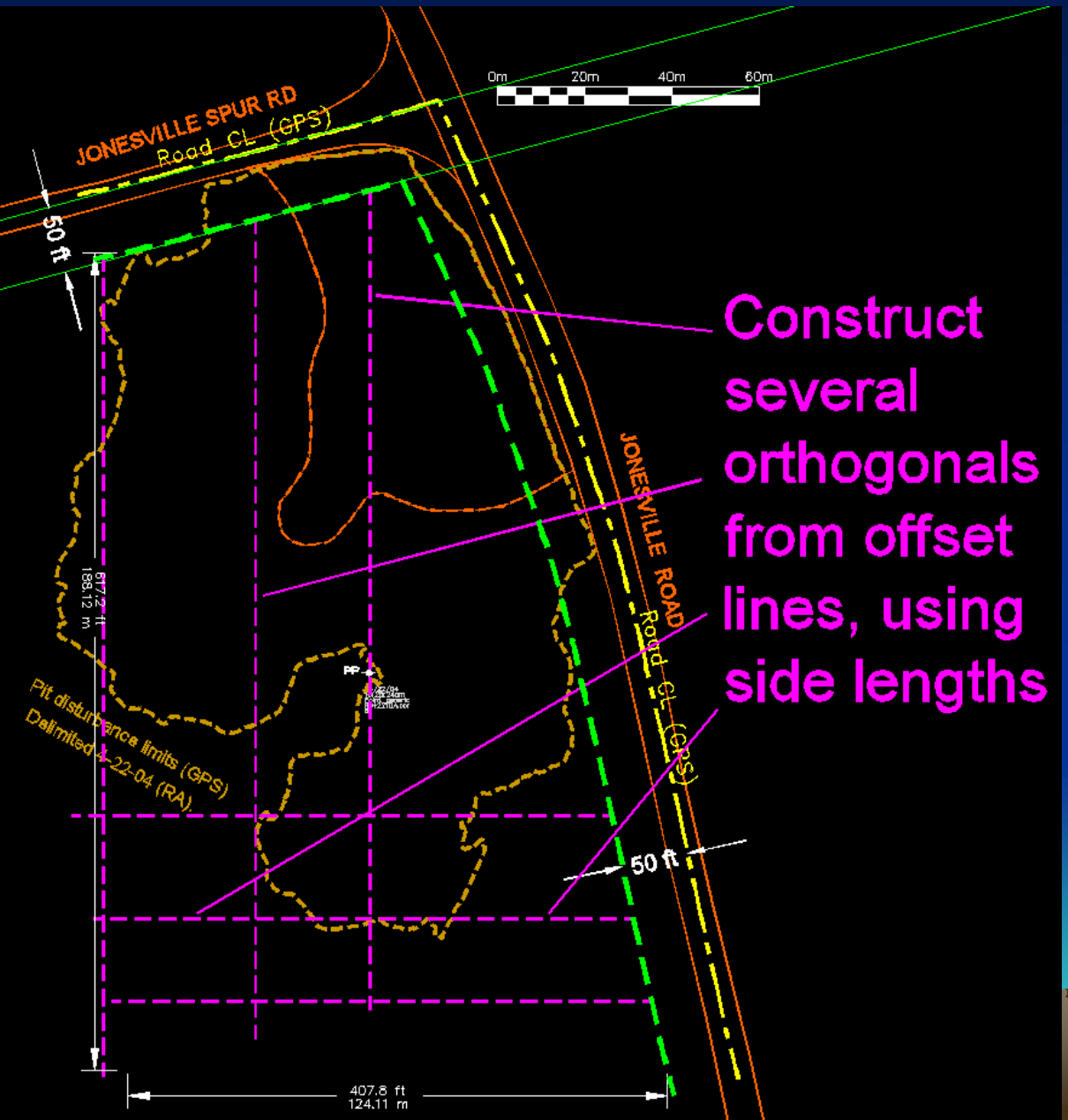


DOT Pit Boundary Permit Reconstruct



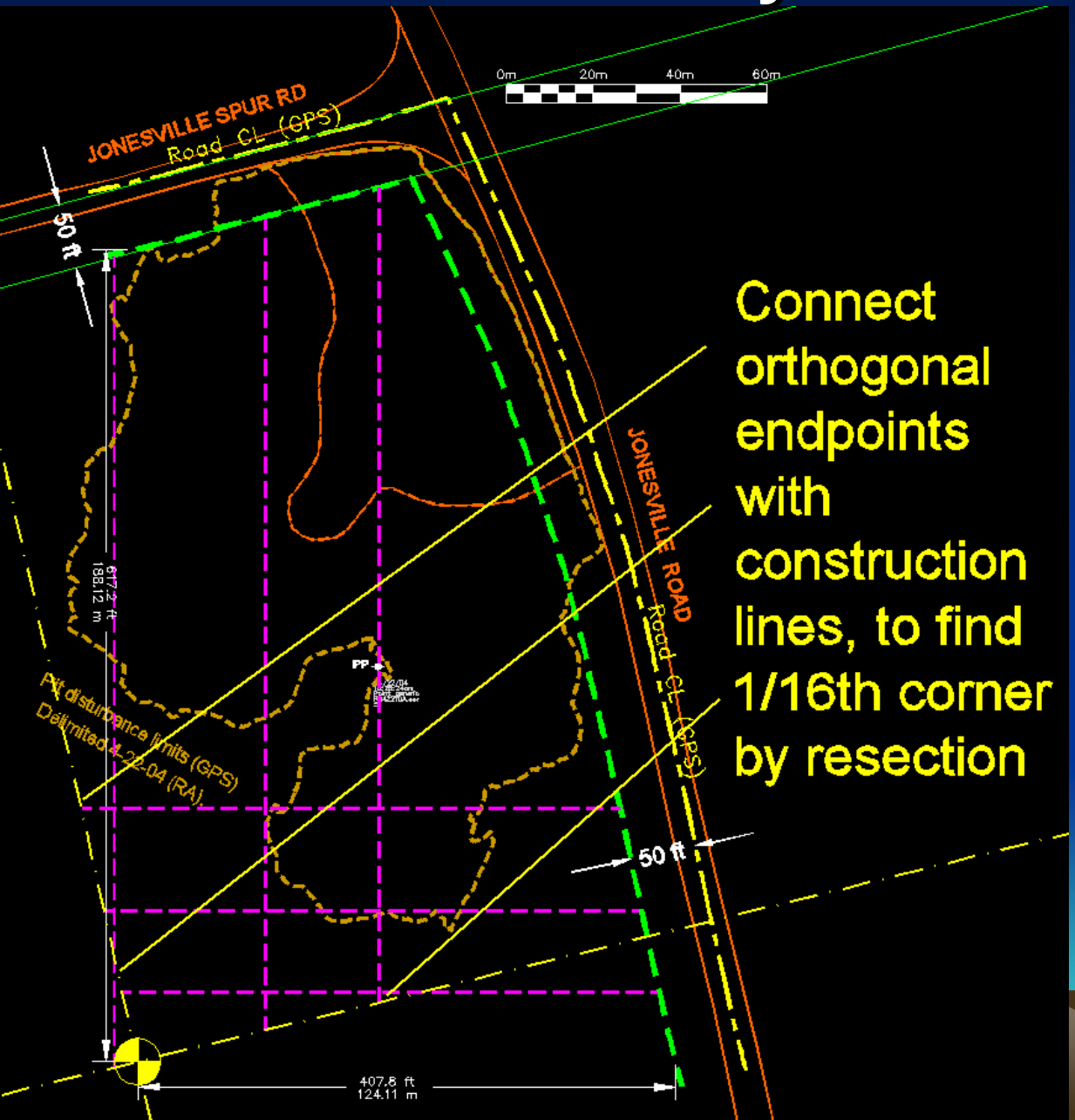
1st -- reconstruct boundary portion at 50 ft offset from GPSd road CL

DOT Pit Boundary Permit Reconstruct



2nd – run N-S and E-W orthogonals from offset lines, using the West and South side lengths

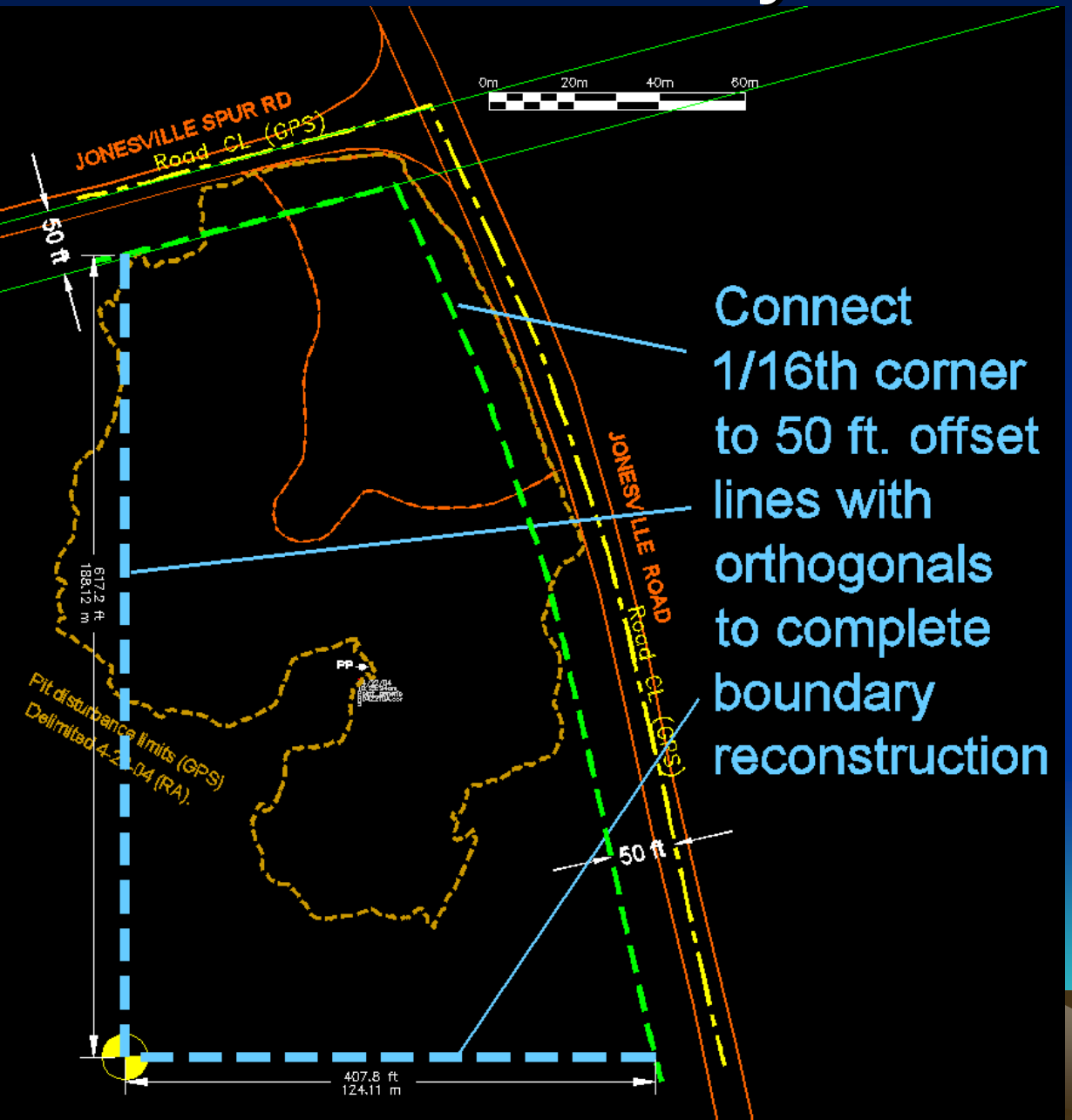
DOT Pit Boundary Permit Reconstruct



Connect orthogonal endpoints with construction lines, to find 1/16th corner by resection

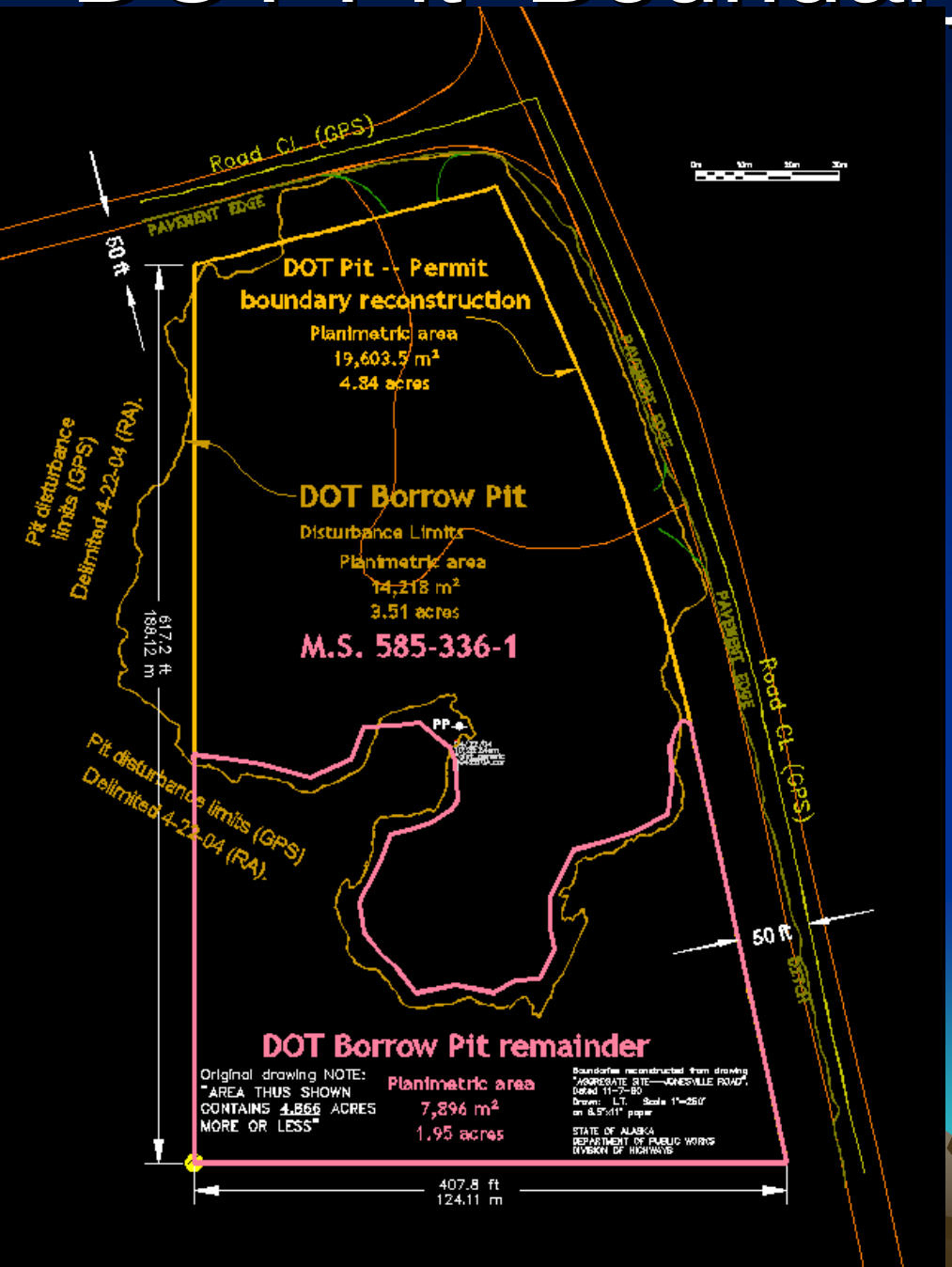
3rd – connect orthogonals' endpoints to resect 1/16th corner.

DOT Pit Boundary Permit Reconstruct



4th – connect 1/16th corner to ROW offset to finish boundary reconstruction

DOT Pit Boundary cf. disturbance



RESULTS

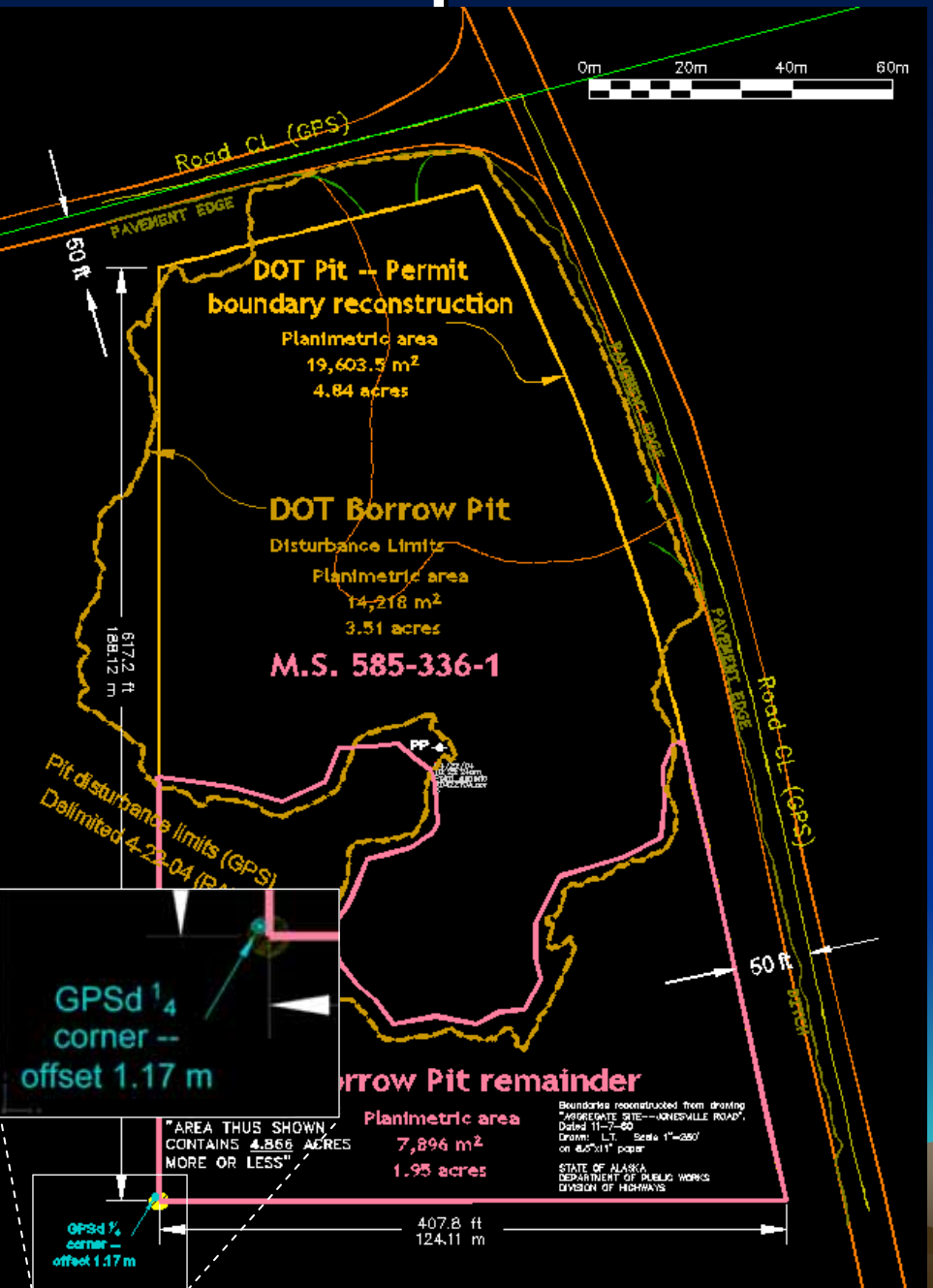
Excavation disturbance strayed somewhat outside west side permit boundary

Reconstructed permit acreage very close to 1960 drawing area -- Δ 0.02 acres

Calculated ~7900 m2 of remaining undisturbed area within permit boundary

More than enough probable gravel volume available for 2005 fires AML construction

Examples – Plat reconstruction



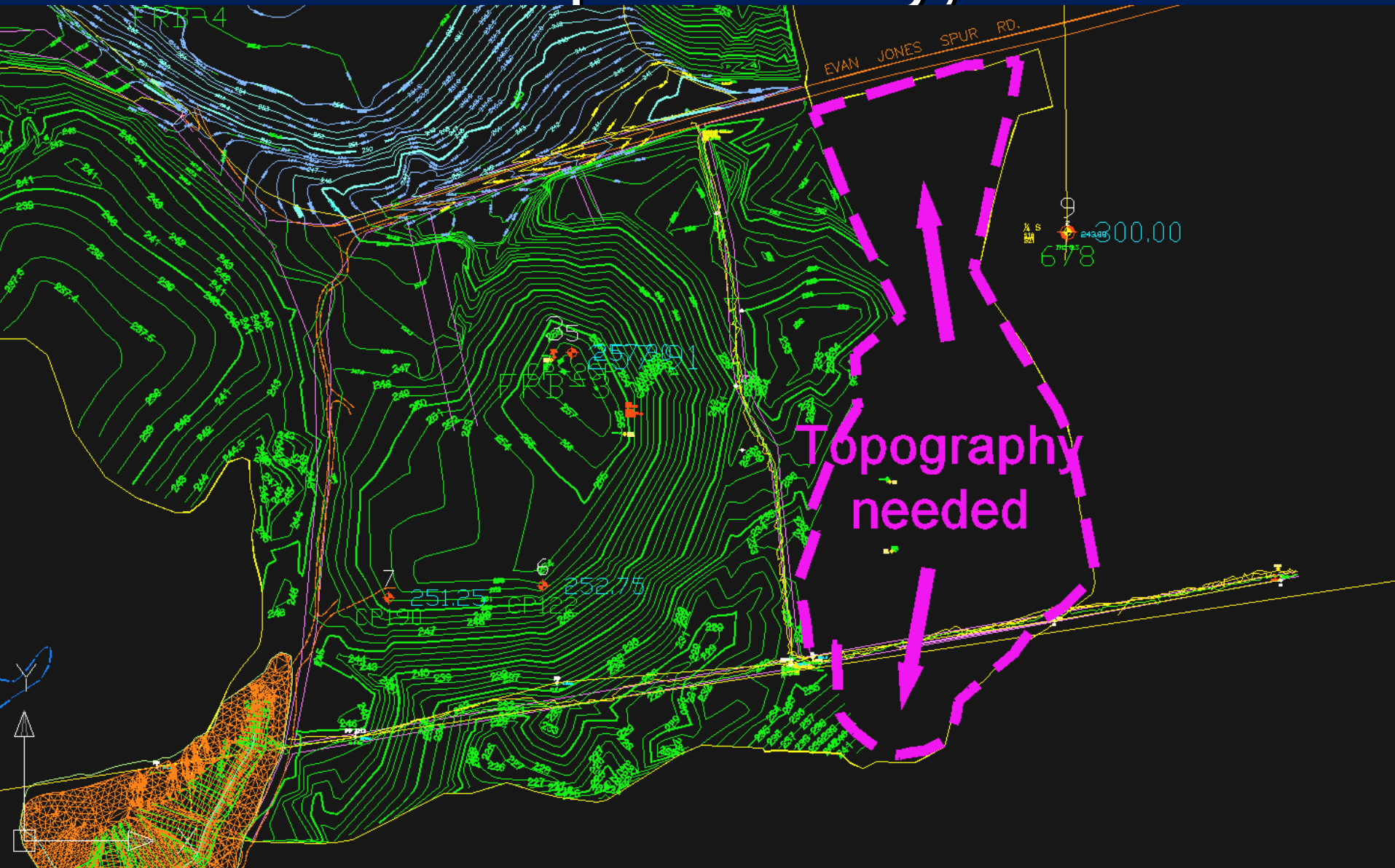
No topography or boundaries surveyed on the ground

Gathered line features on disturbance limits, road centerlines

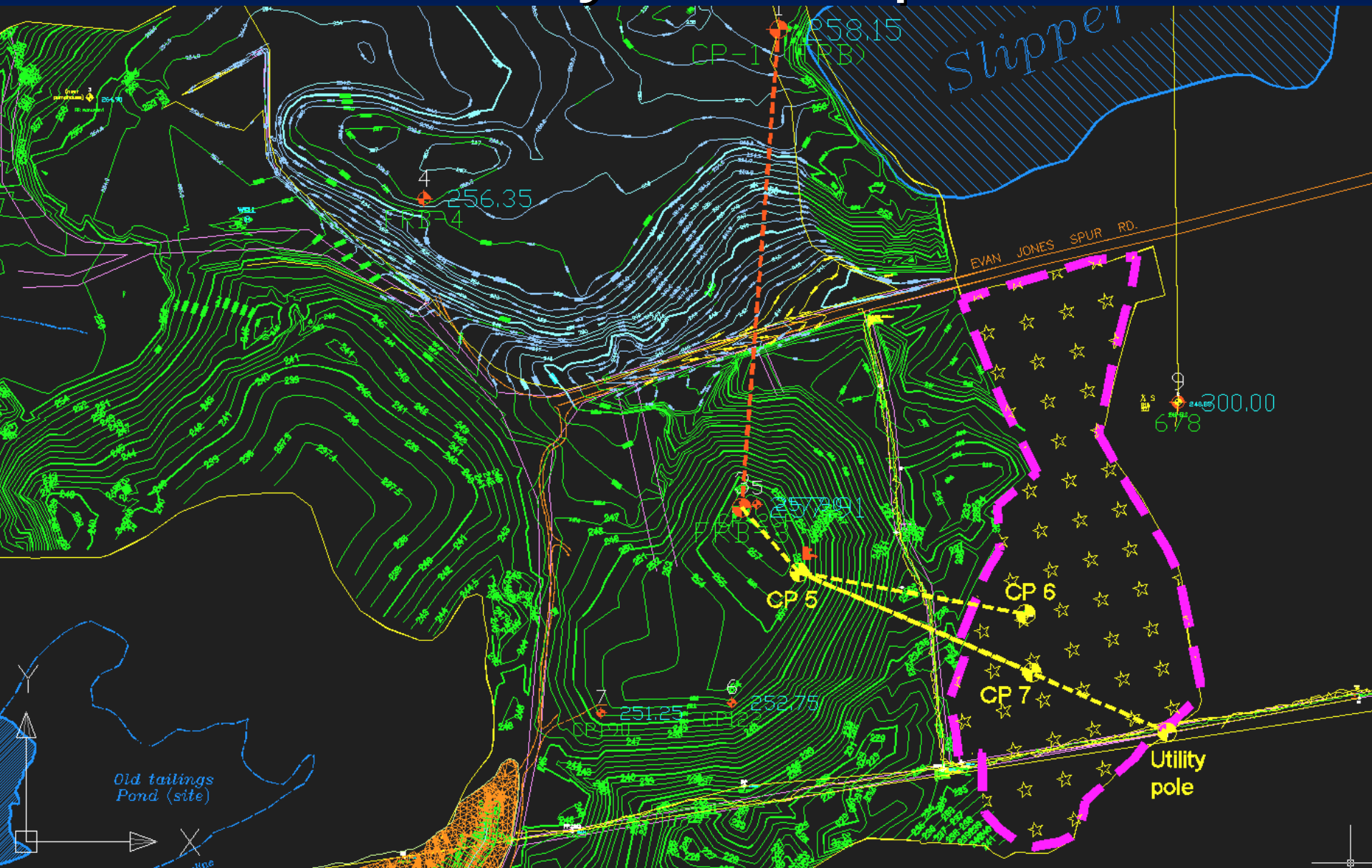
Used corr. line features and 1960 plat dimensions to reconstruct boundaries of permitted gravel extraction area

Calculated remaining area to estimate probable borrow volumes

Survey error detection & correction
E side S pile survey, 2-04

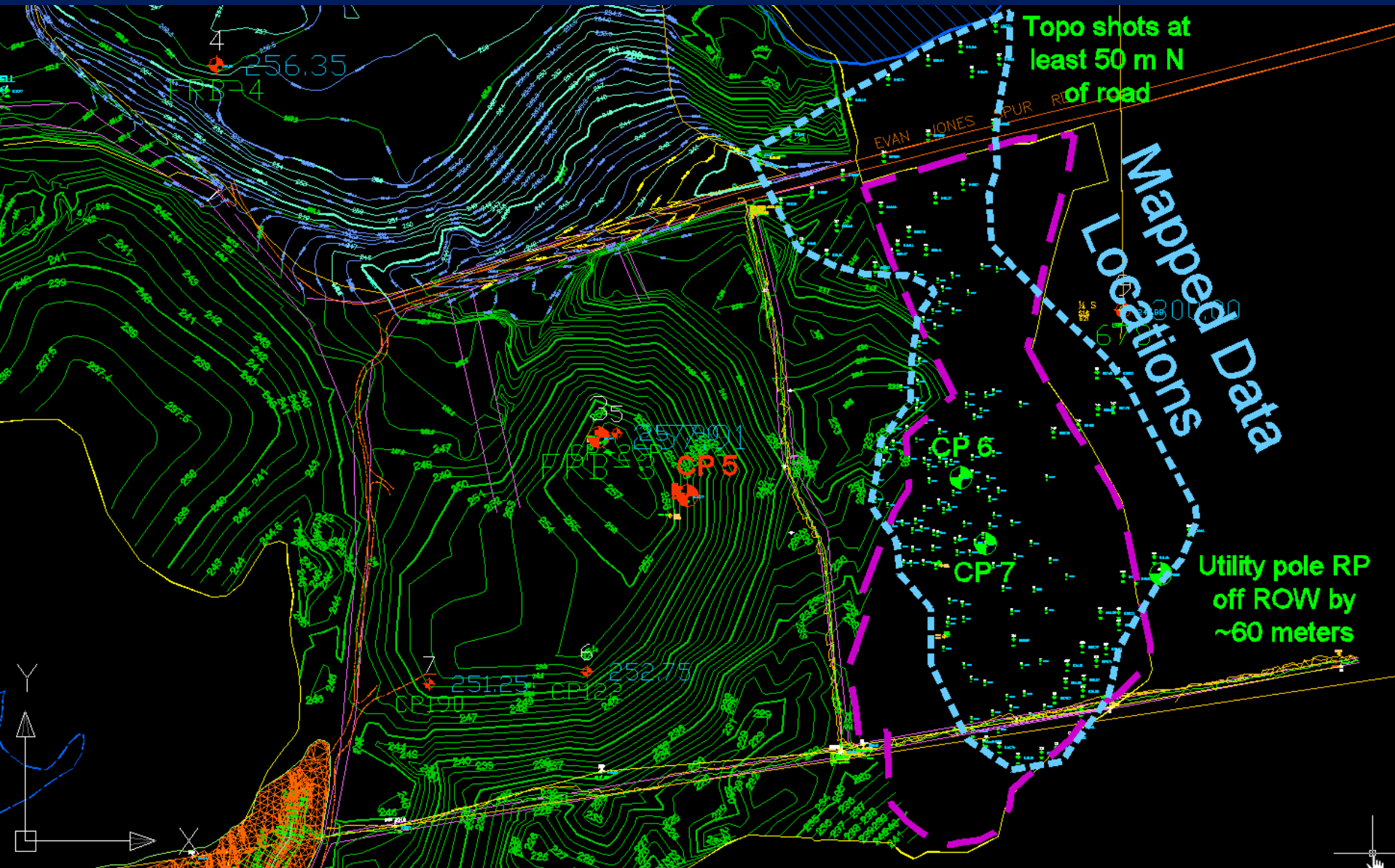


BS -- FS – Established control & RPs, Surveyed data pts



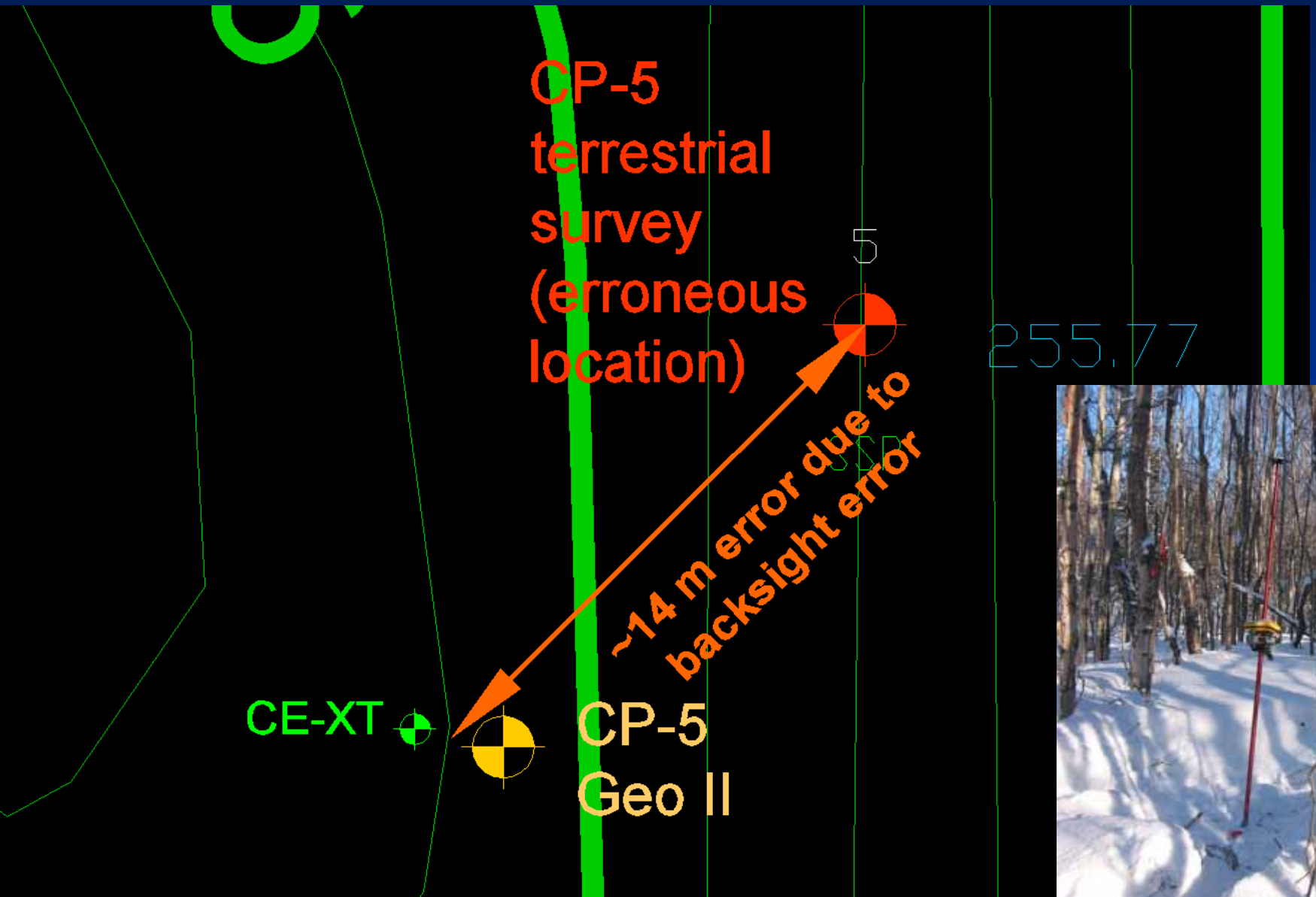
Back in Office – data didn't look right

Data, RPs displaced too far N

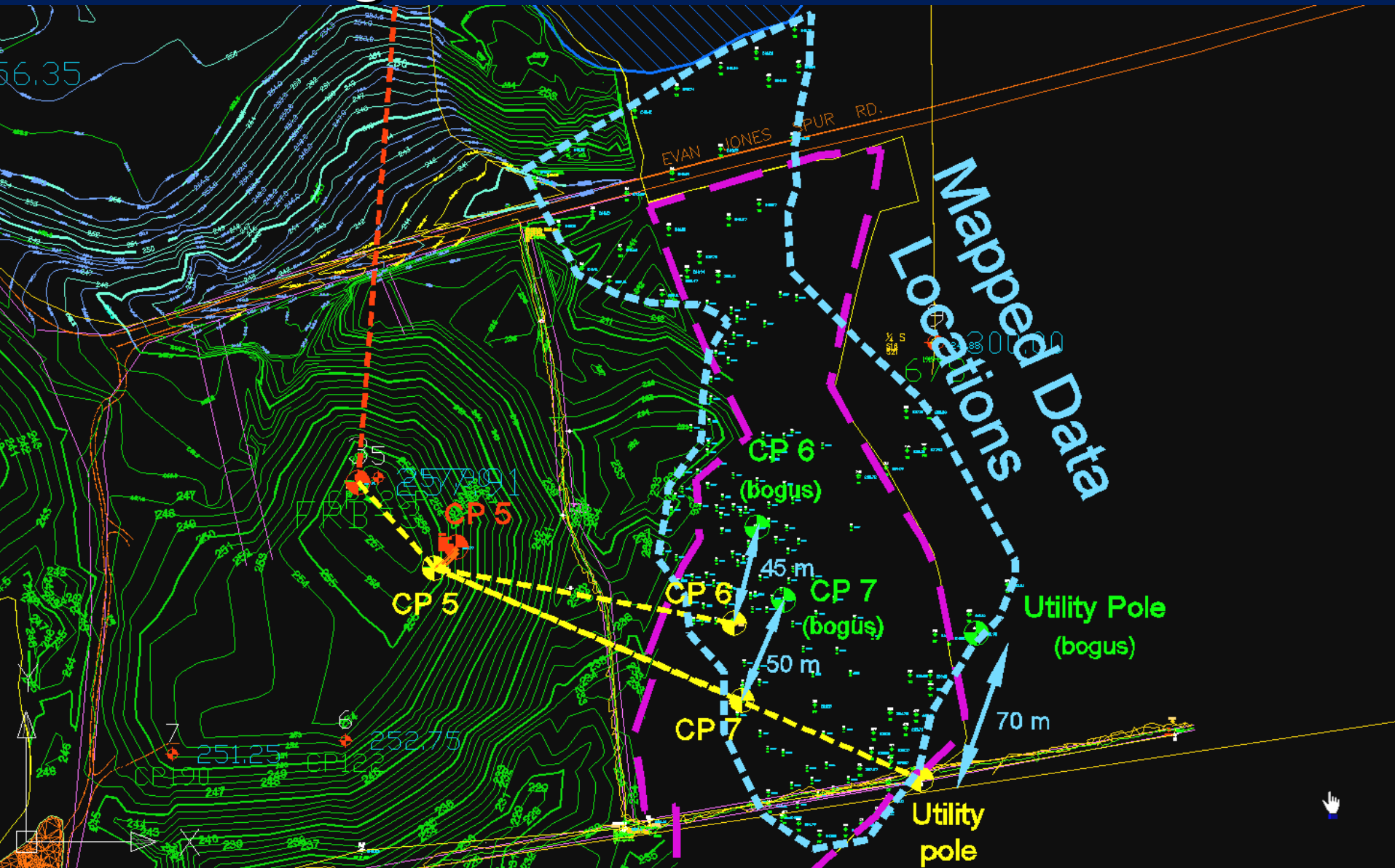


Returned to field – GPSd control PTs

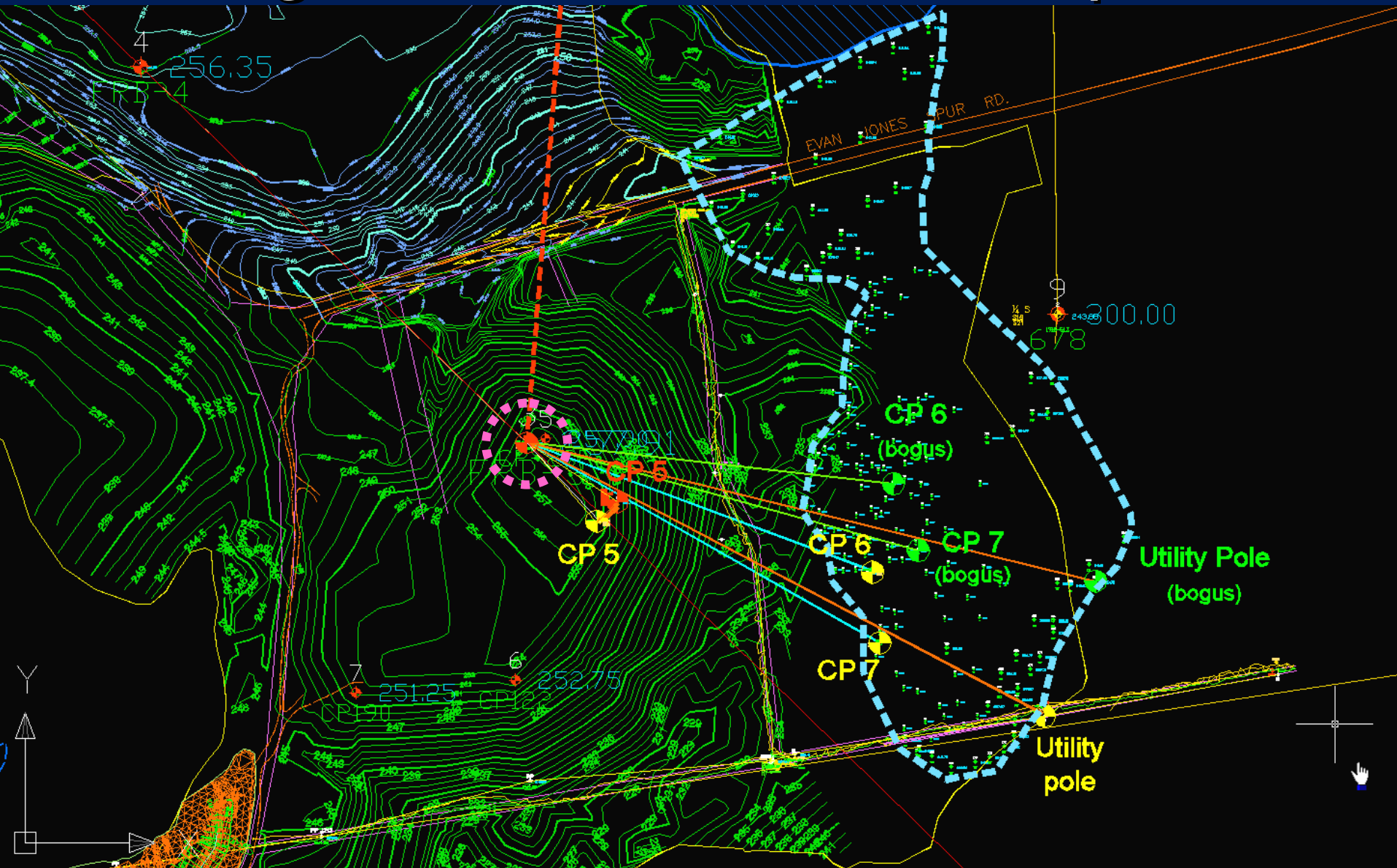
Waypoint location of CP#5 in error



Back in office – mapped corrected GPS vs. bogus control & RP locations

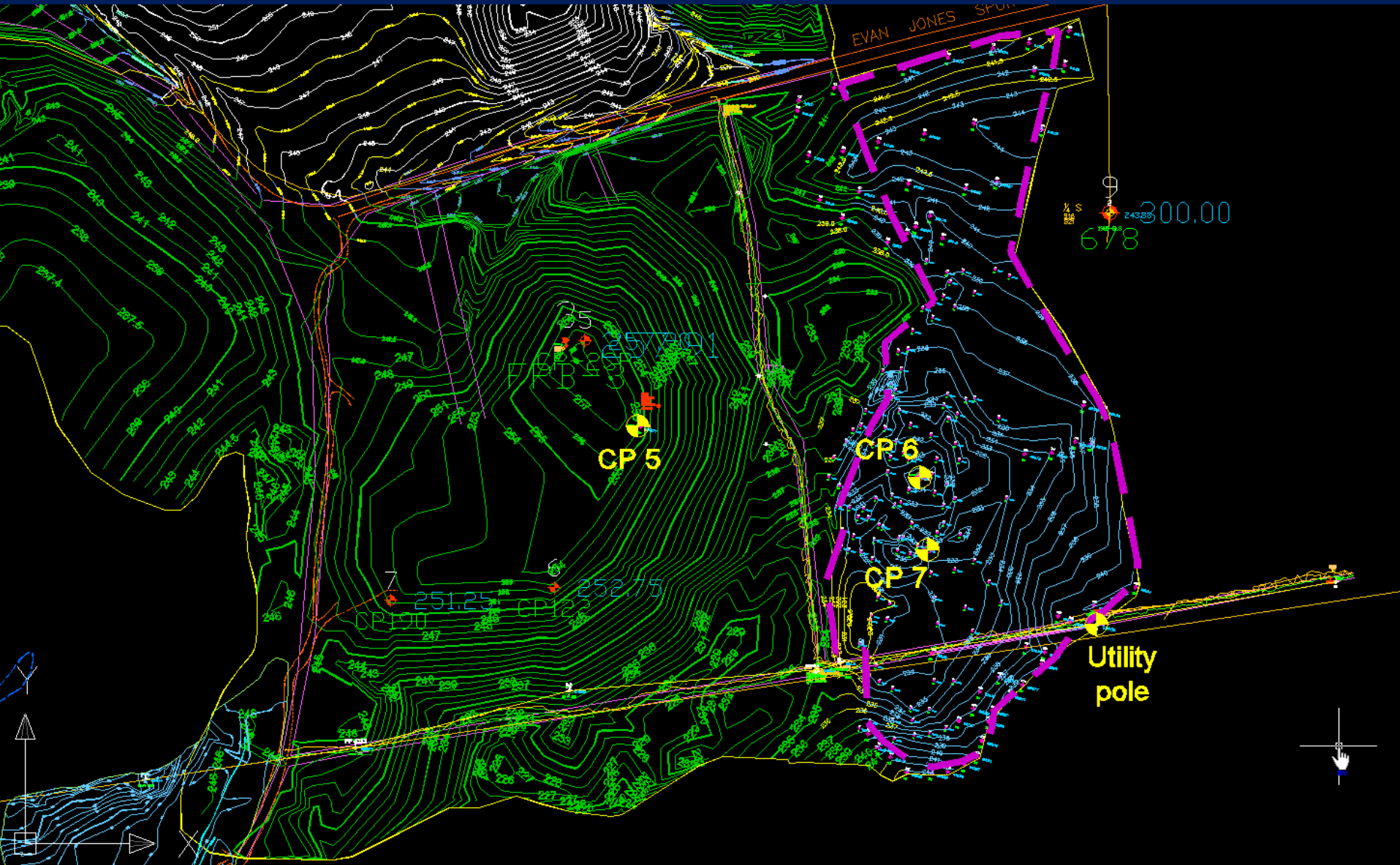


Constructed rotation ray pairs for each bogus-to-GPS Control Pt. pair

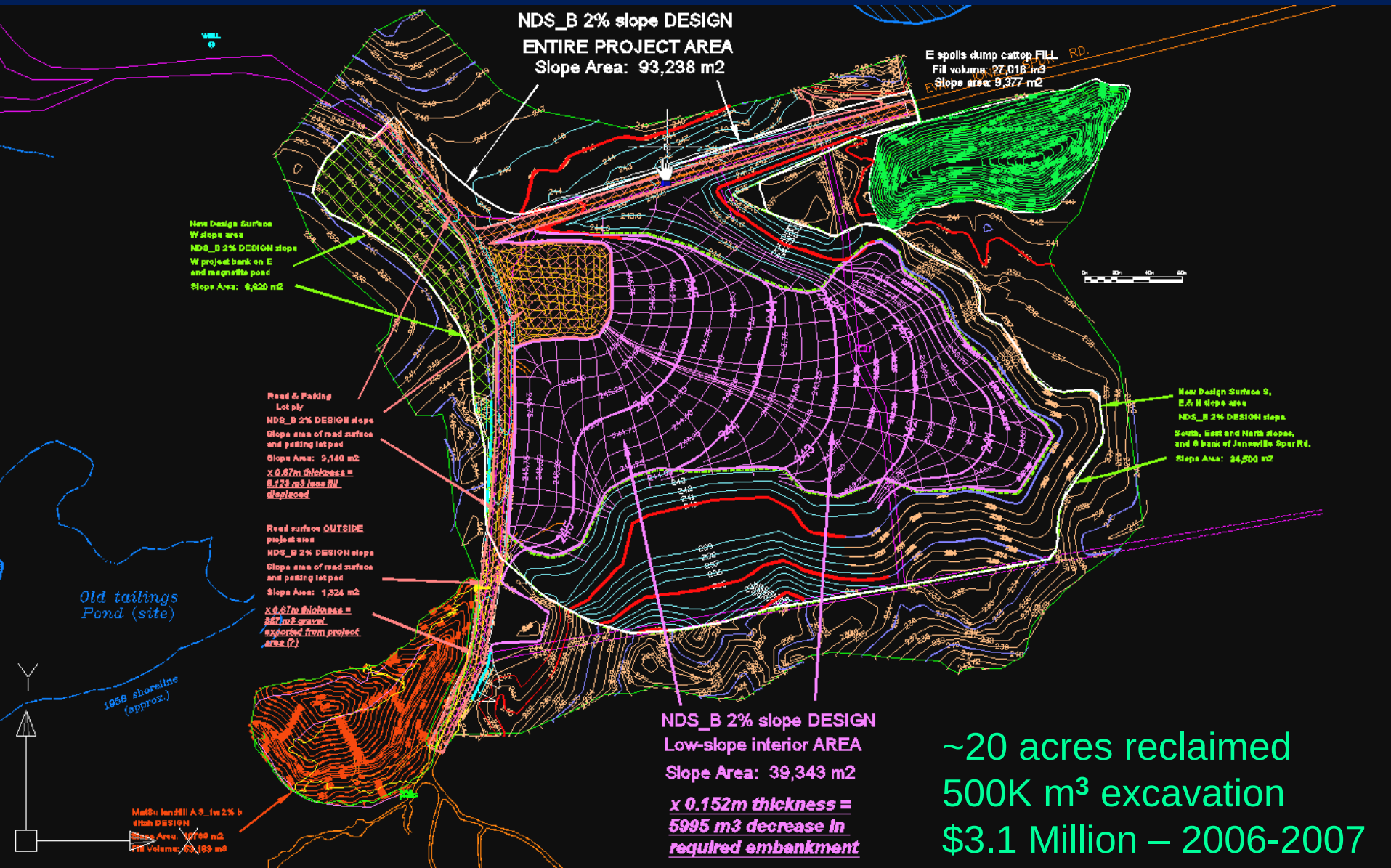


Rotated survey data about CP3 using bogus-to-GPS Control Pt. pairs

Constructed S pile E side OG contours from GPS-corrected survey data



Based Design & volumetrics off OG contours & borehole data



~20 acres reclaimed
500K m³ excavation
$3.1 Million – 2006-2007

JFII– MatSu Dump Composite

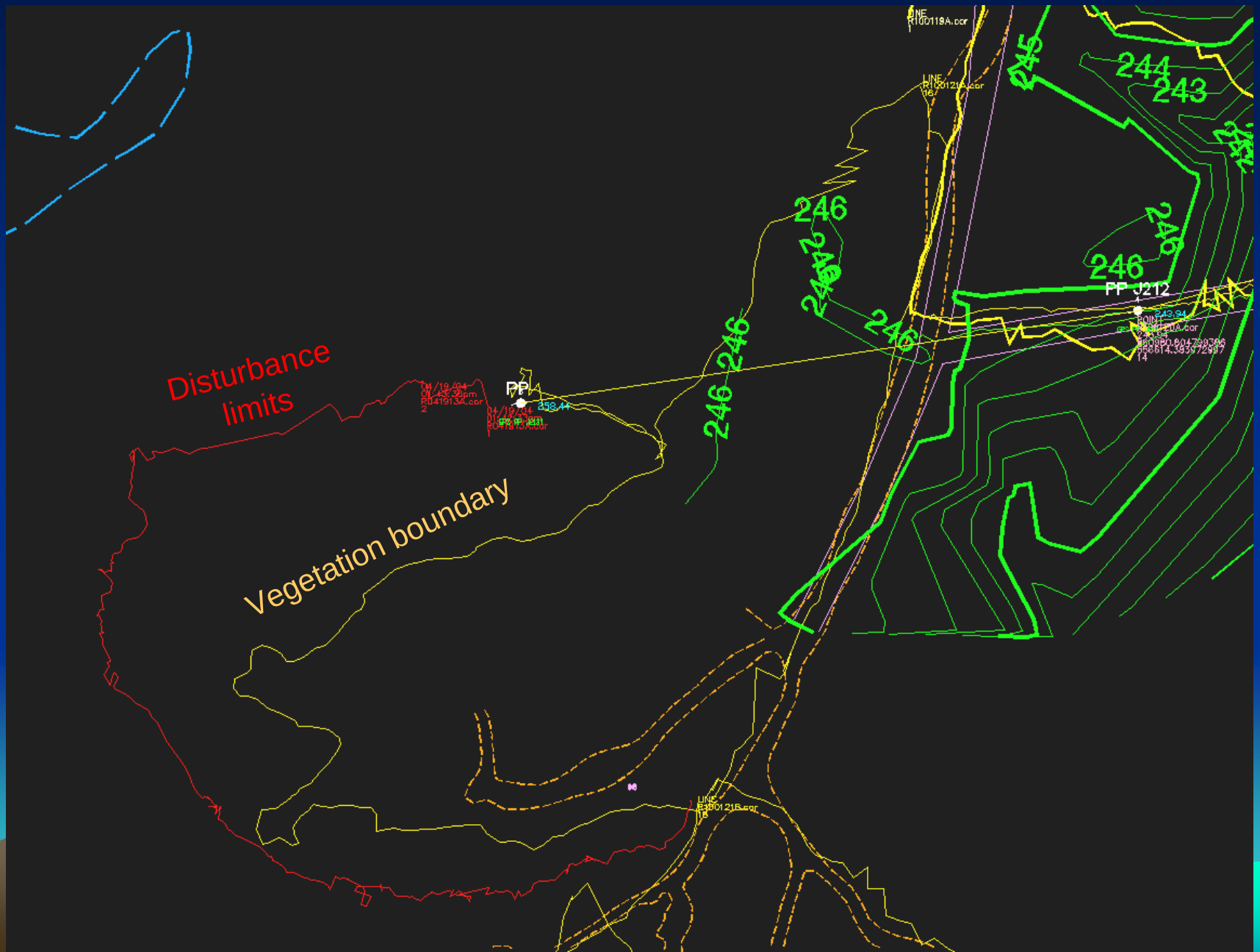
View NE -- 4-22-2004

SW corner of project

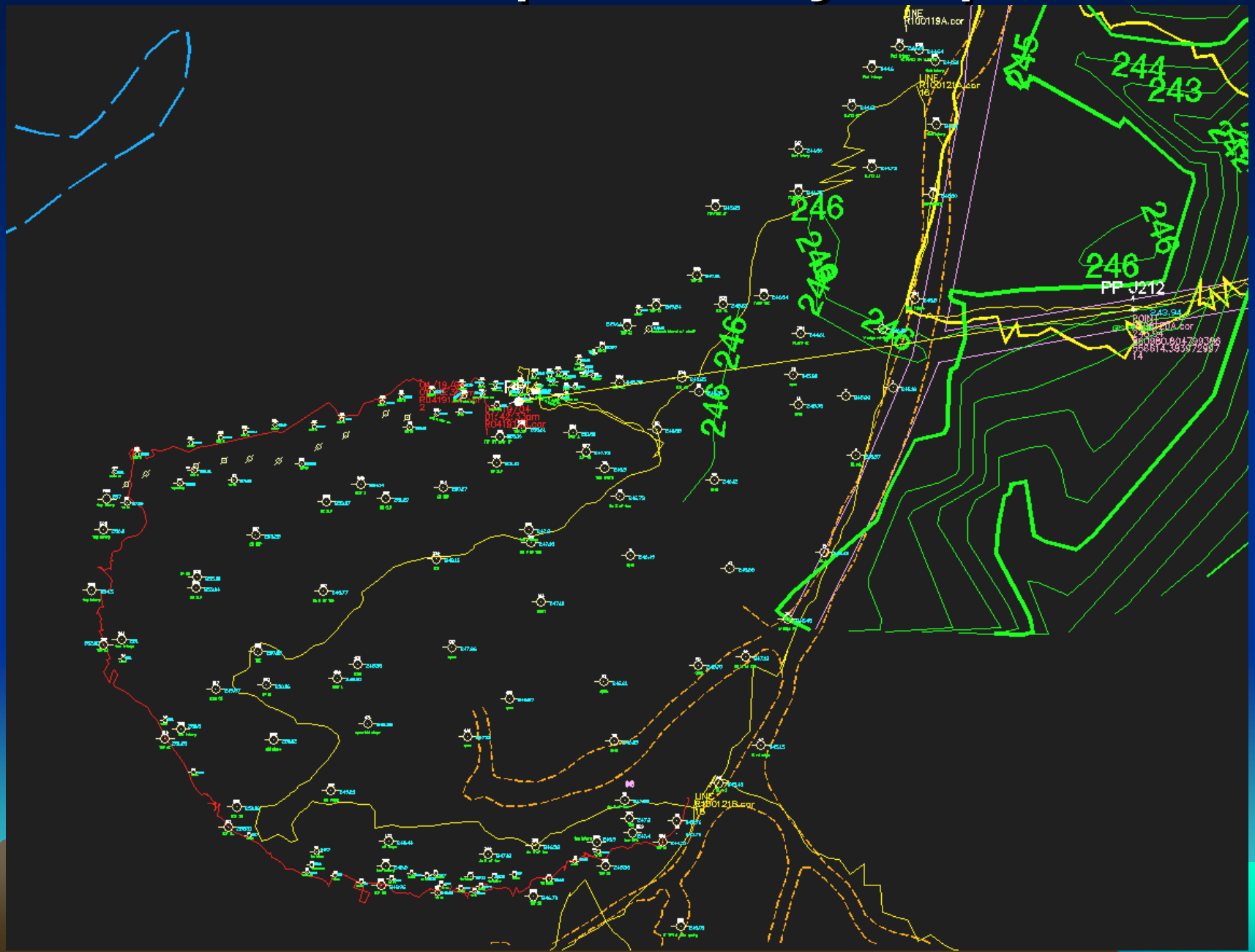
Design spoils stockpile area

Examples – MatSu Dump Survey

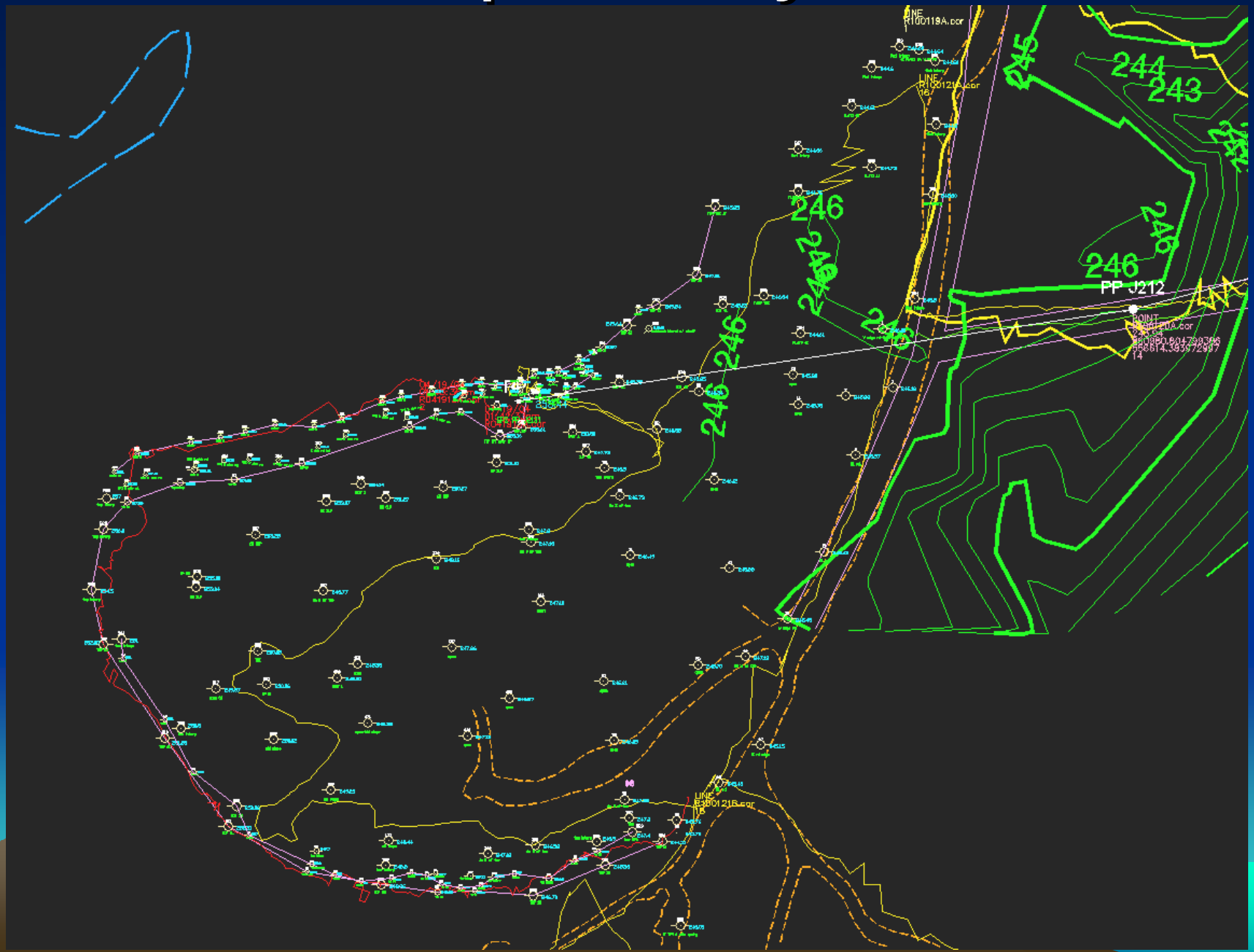
MatSu Dump Survey -- boundaries



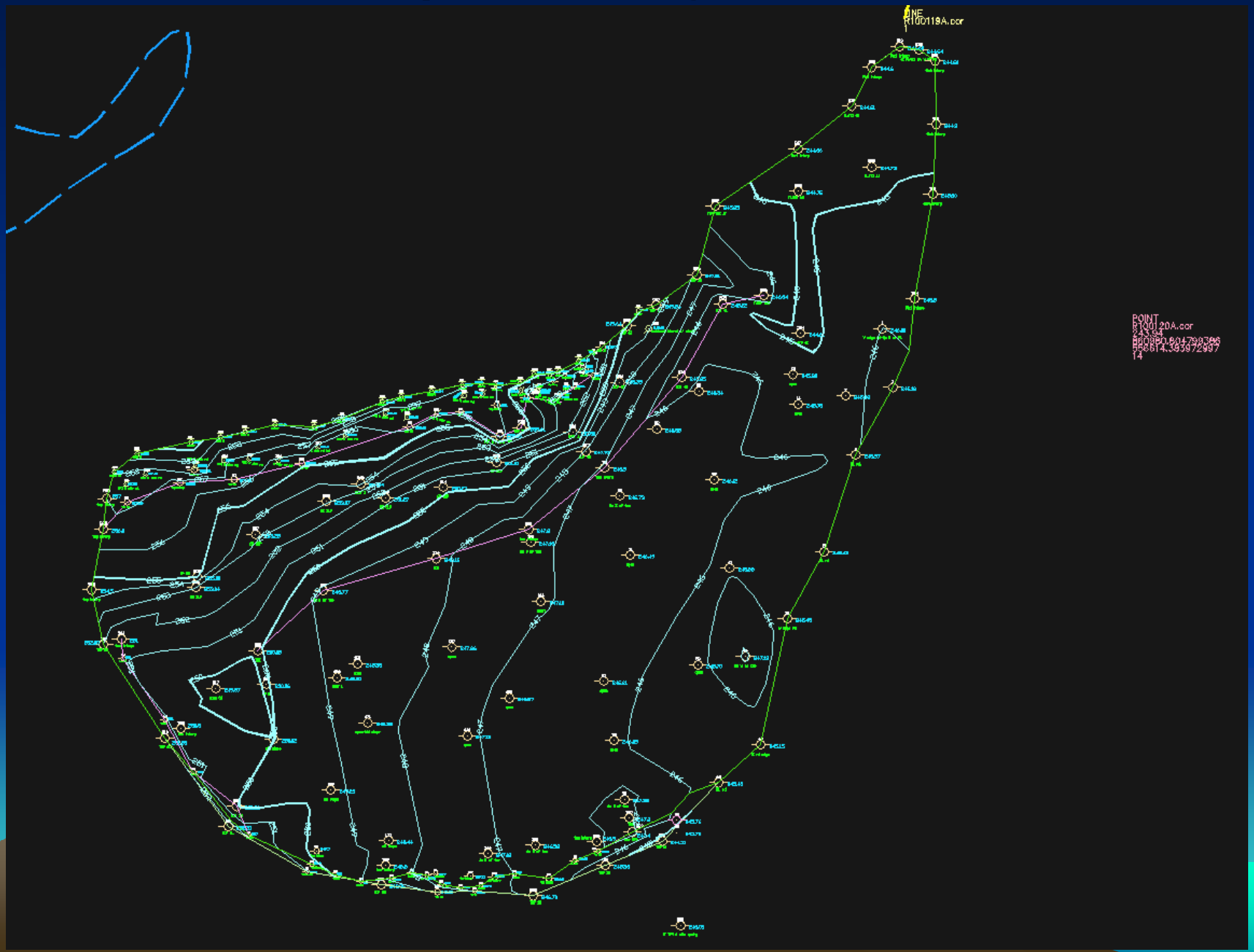
MatSu Dump Survey -- points



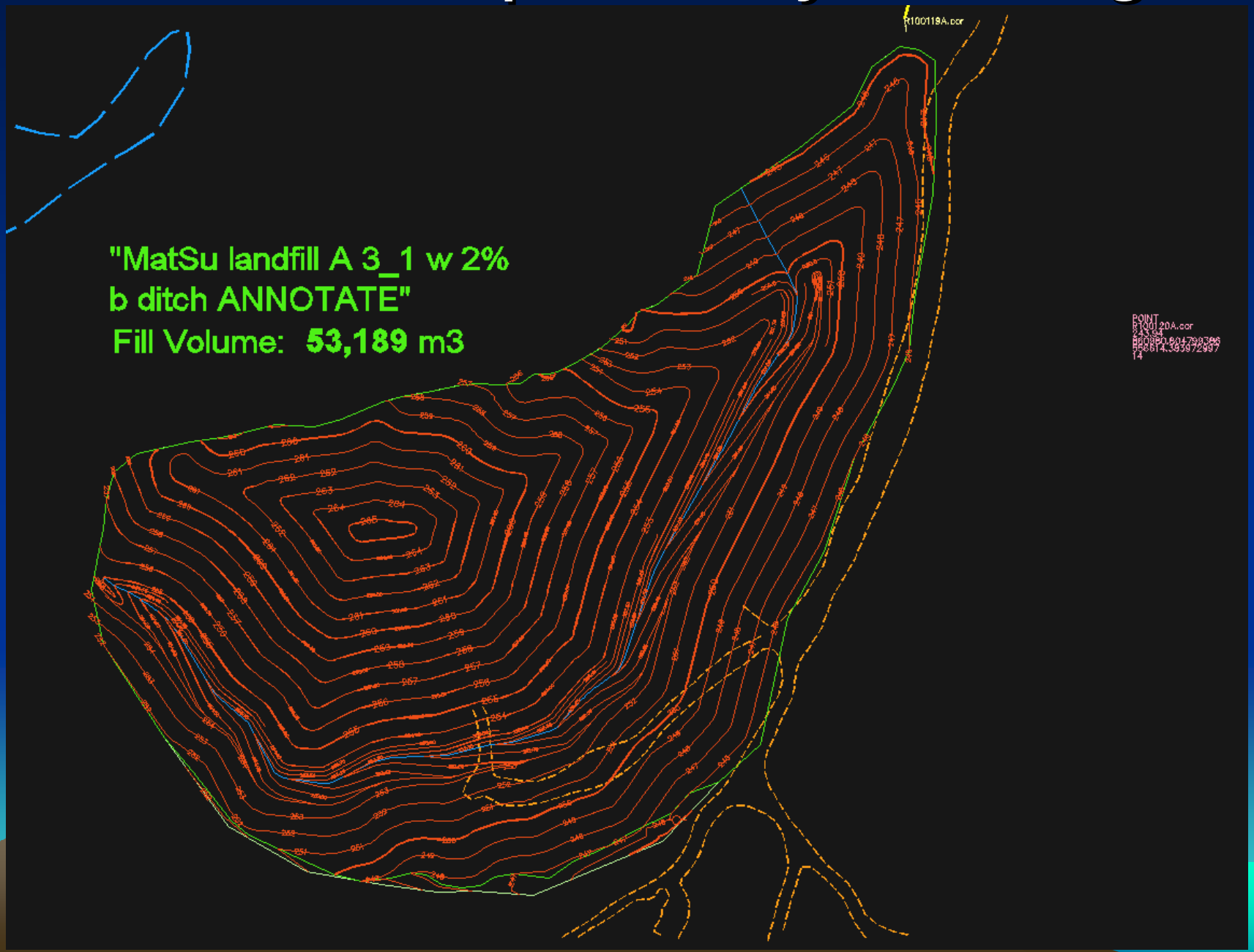
MatSu Dump Survey -- brklines



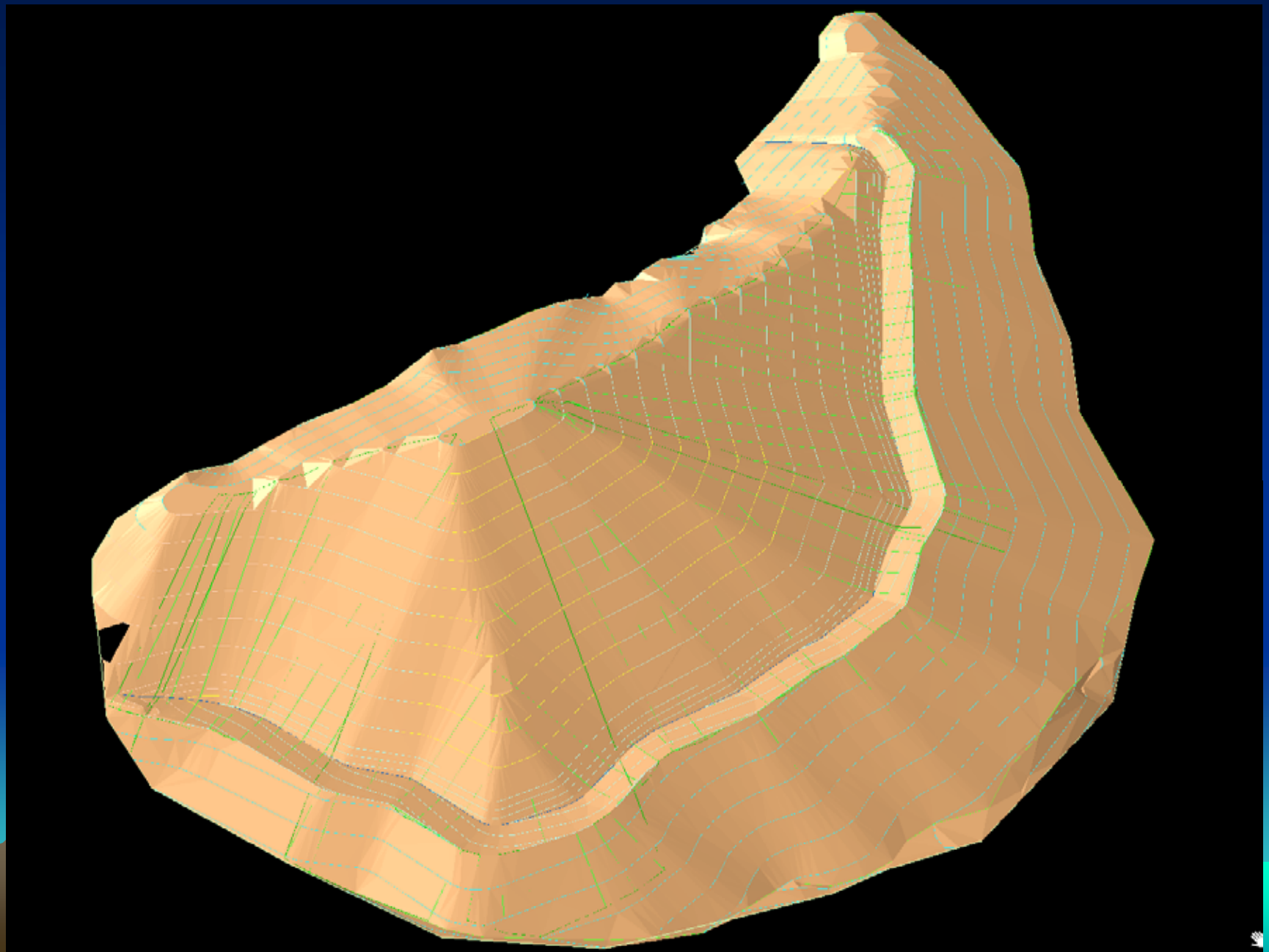
MatSu Dump Survey – OG contours



MatSu Dump Survey -- design



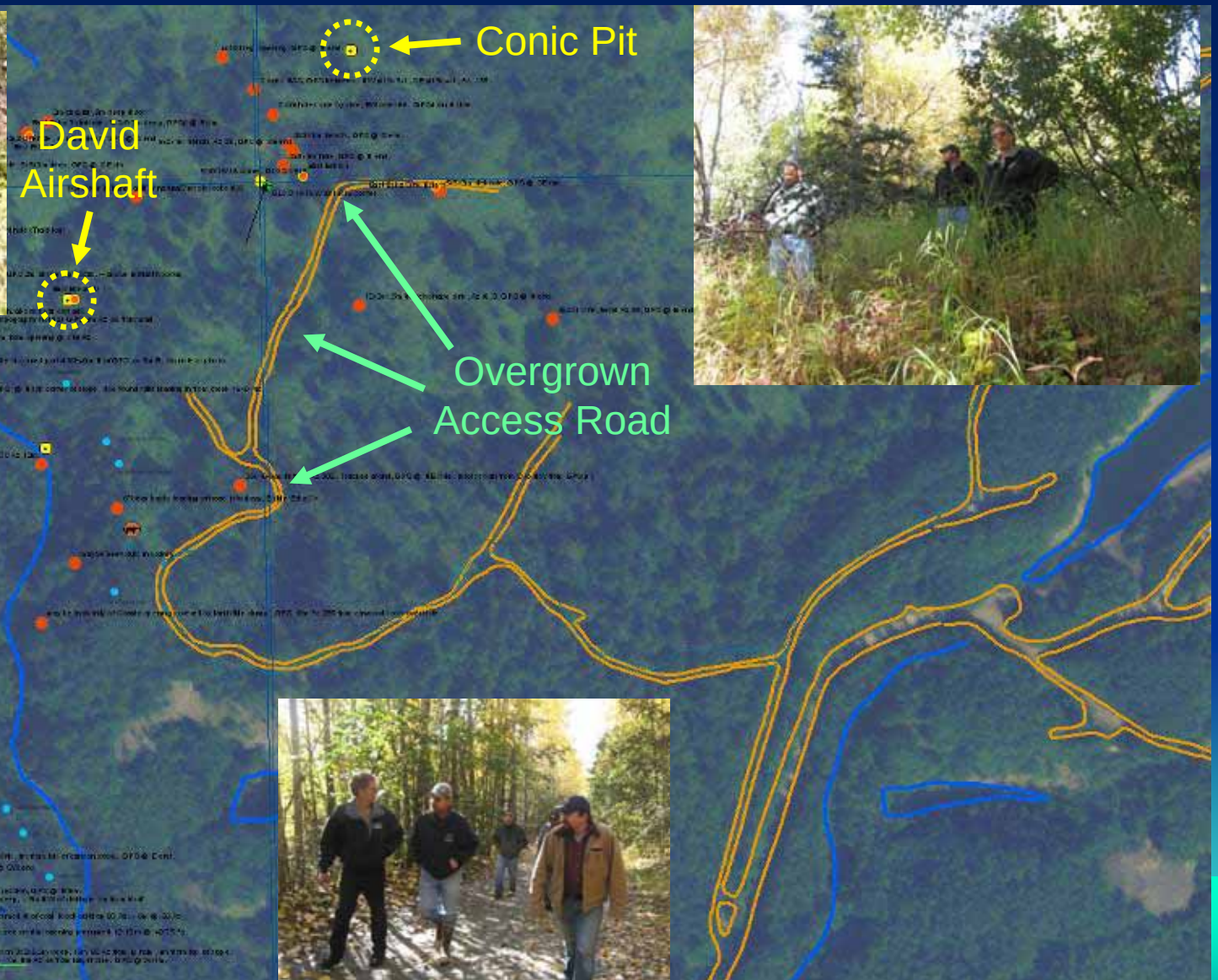
MatSu Dump Design – 3D



MatSu Dump Asbuilt – May 2007

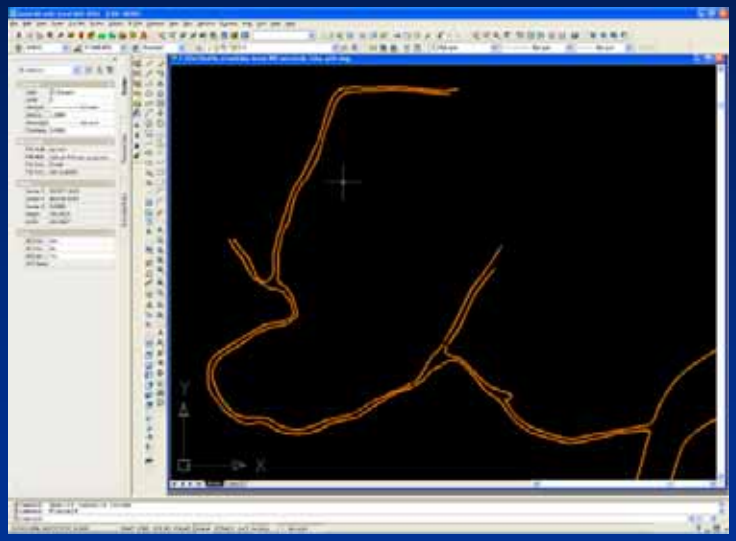
East Eska PhII – Old mining Road

Question: How to find it?

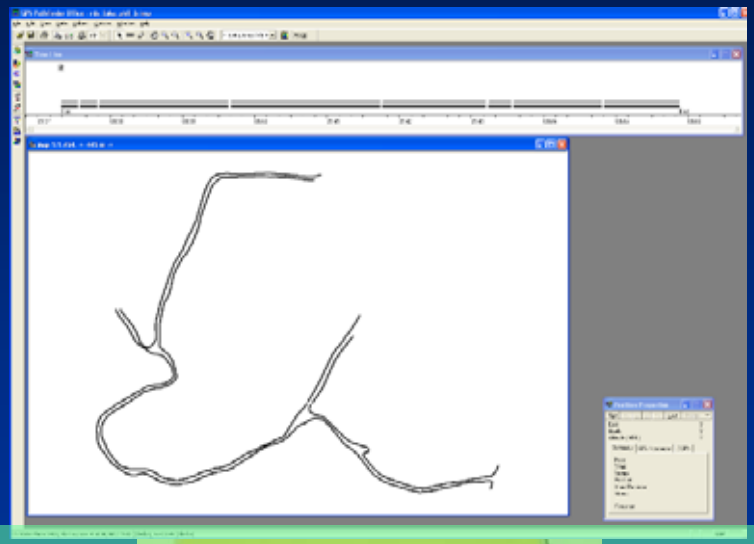


To Walk the Old mining Road Trace
Put it on the GPS

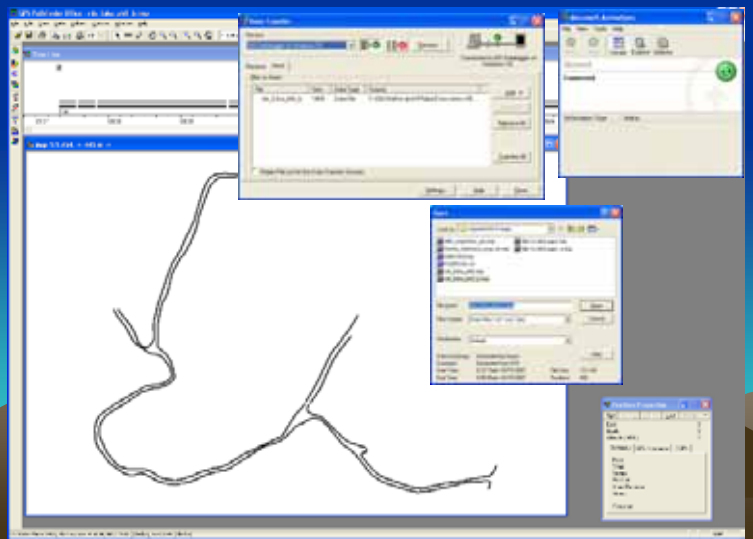
1. Export from CAD as shapefile or DXF



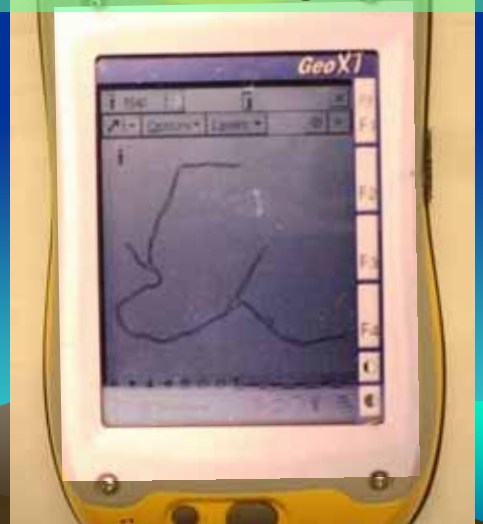
2. Import into PFO, save as *.imp file



3. Upload *.imp file into a Trimble GPS



4. Ready for field use – follow the feature on the ground.



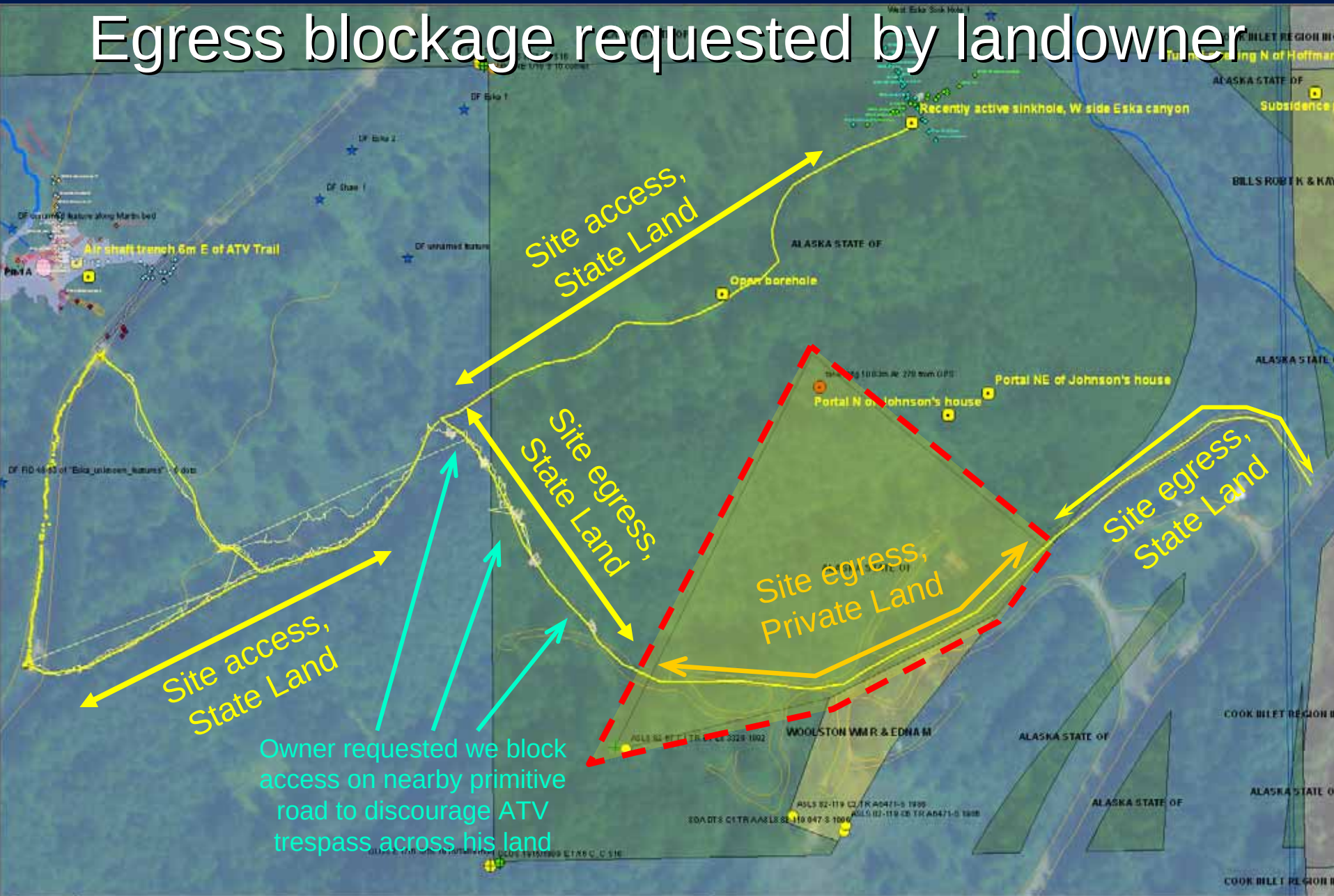
Walk the Old mining Road Trace
Follow the GPS file

Marking access for heavy equipment road

Easier to follow road when not overgrown

Eska PhII – Work Site / Landownership Clarification

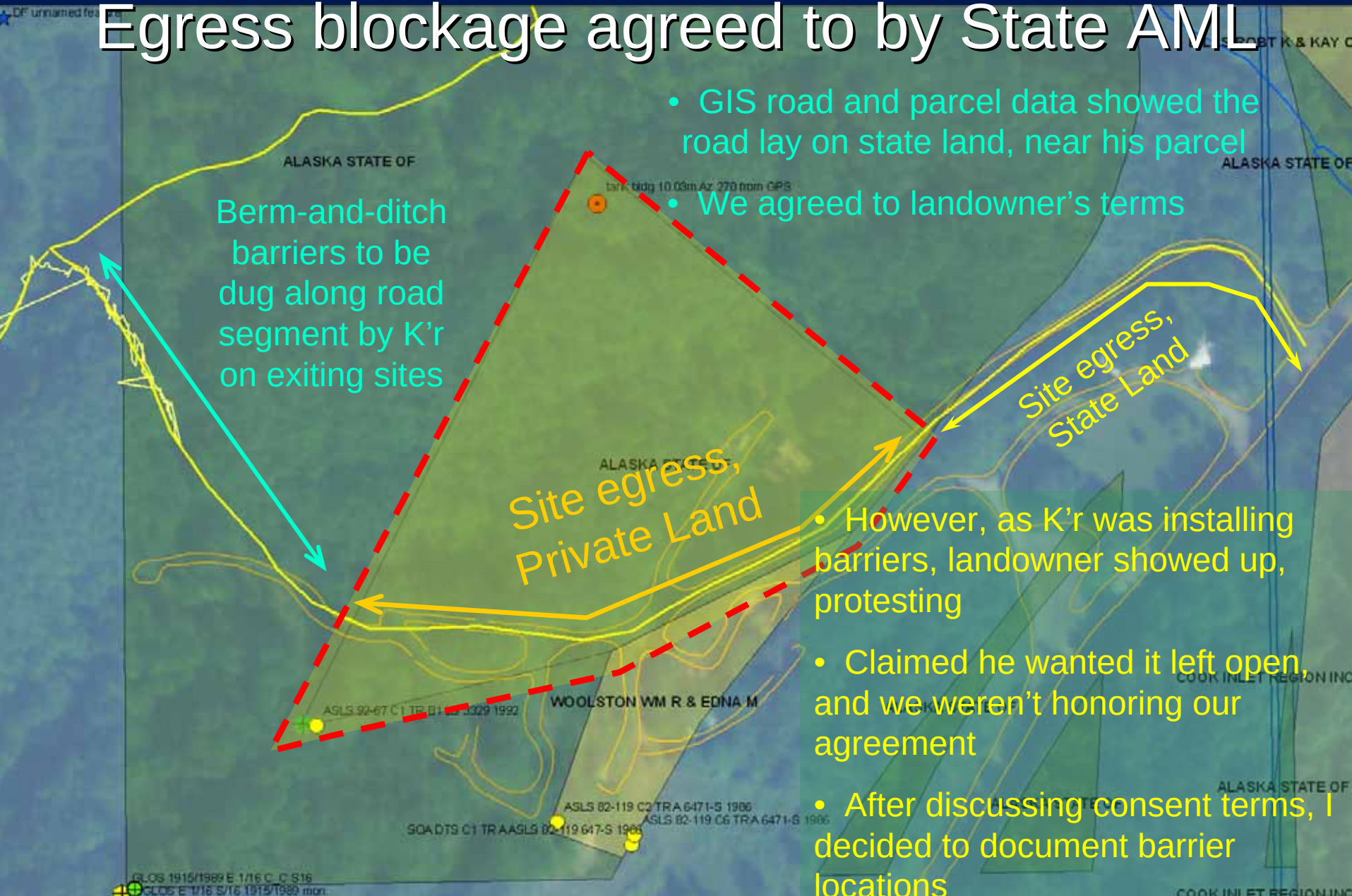
Egress blockage requested by landowner



Eska PhII – Land Ownership Clarification

Egress blockage agreed to by State AML

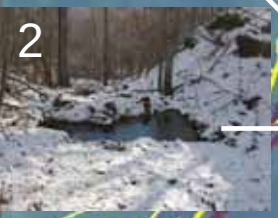
- GIS road and parcel data showed the road lay on state land, near his parcel
- We agreed to landowner's terms

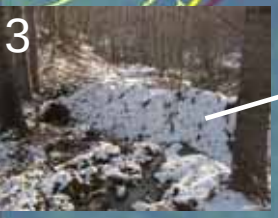


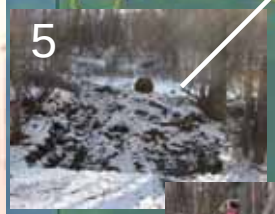
- However, as K'r was installing barriers, landowner showed up, protesting
- Claimed he wanted it left open, and we weren't honoring our agreement
- After discussing consent terms, I decided to document barrier locations

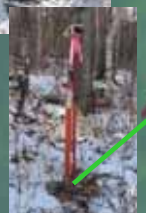
Eska PhII – Land Ownership Clarification

Egress blockage & property lines documented









Terrasync NIF tracklog pts

ESKA Water Tower

GPS asbuilt locations of trench and berms

Ribboned marker sites

~36 m

ALASKA STATE OF

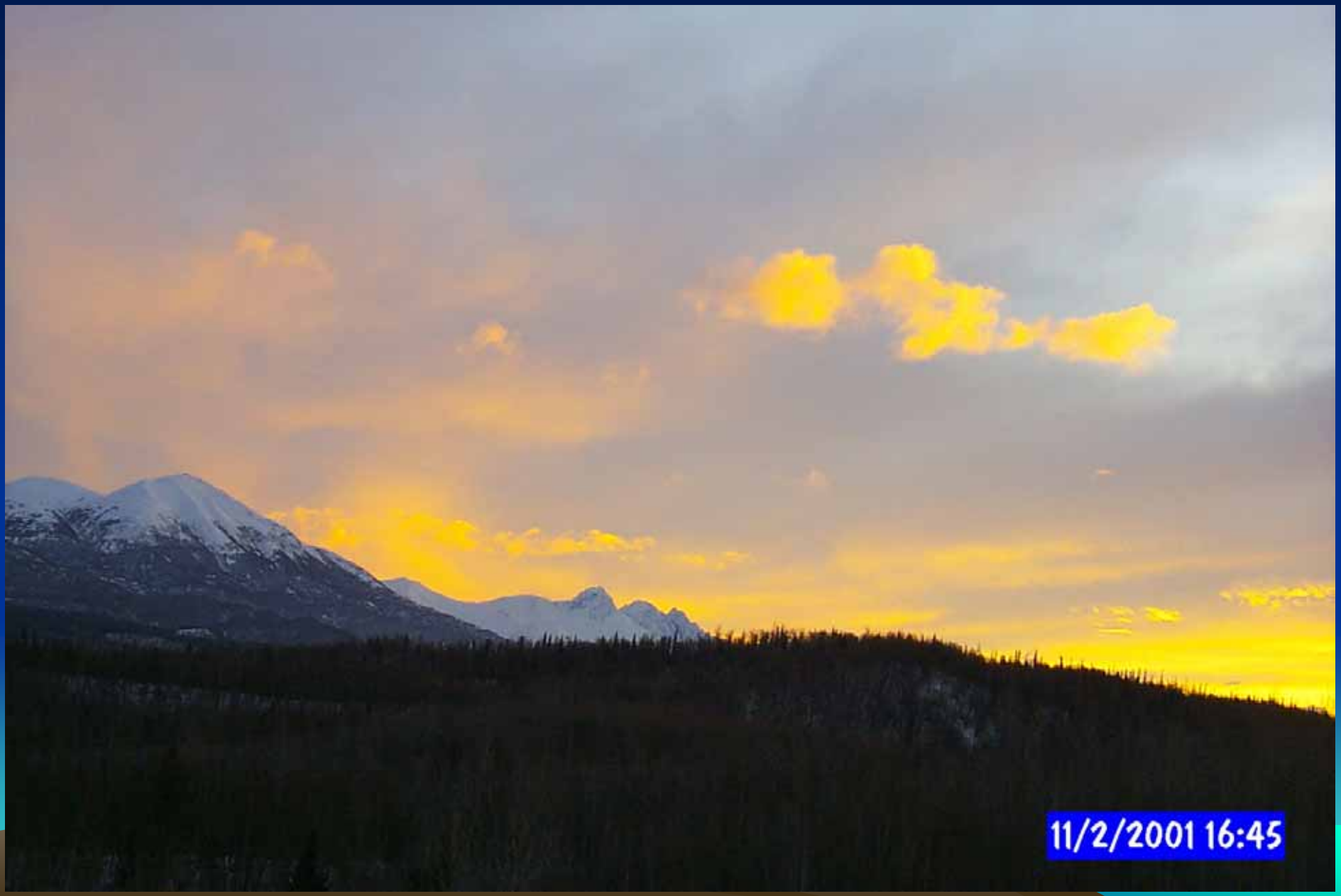
WOOLSTON WM R. & EDNA M

ALASKA STATE OF

- Uploaded parcel into Terrasync as *import file on CE/XT, off GIS
- Traced GPS rover file polygons around asbuilt barriers
- Took point data at parcel corner
- Traced GPS parcel line nearest divots, ribboned
- Collected 1s NIF tracklog data of all field work

FINIS

FINIS



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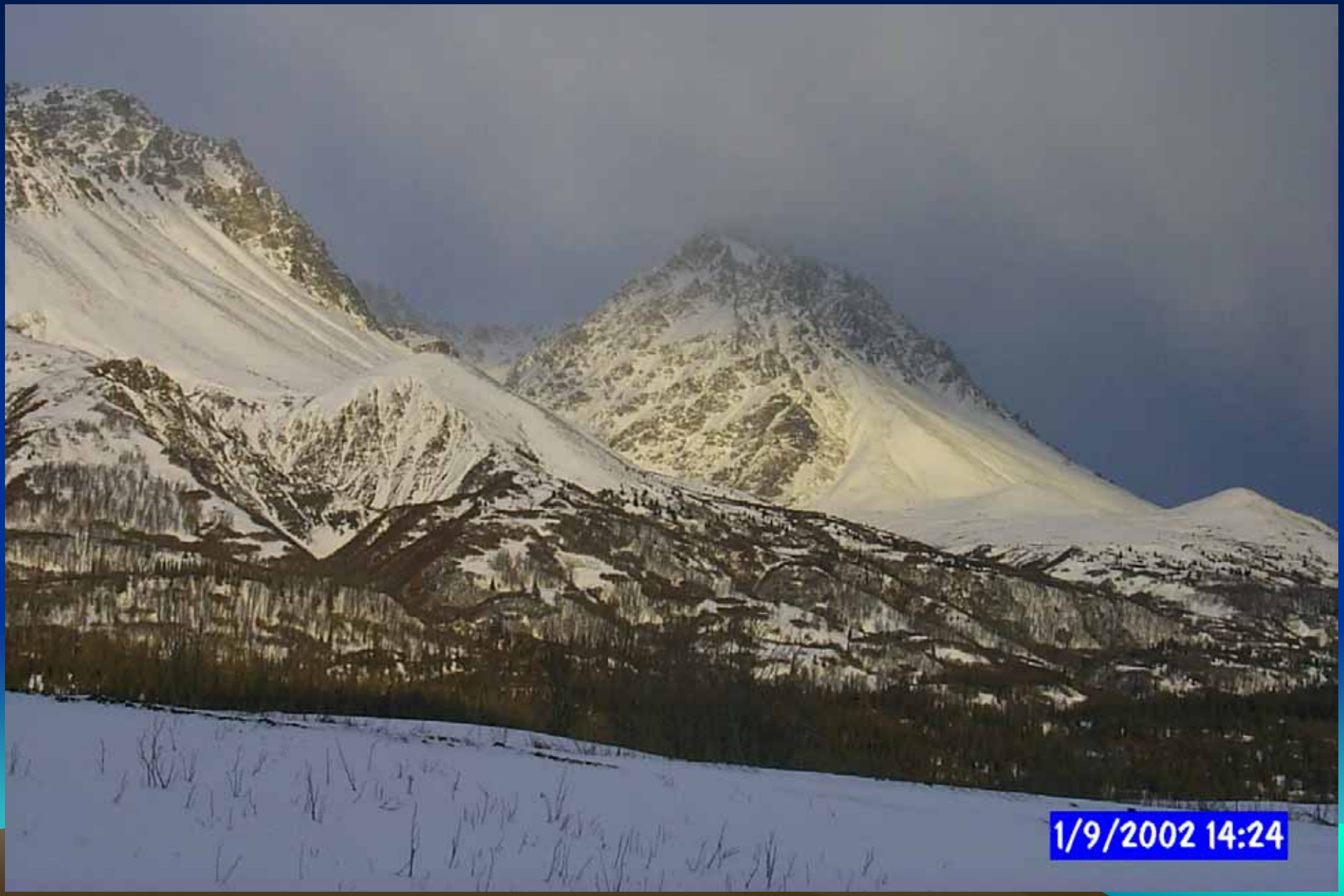

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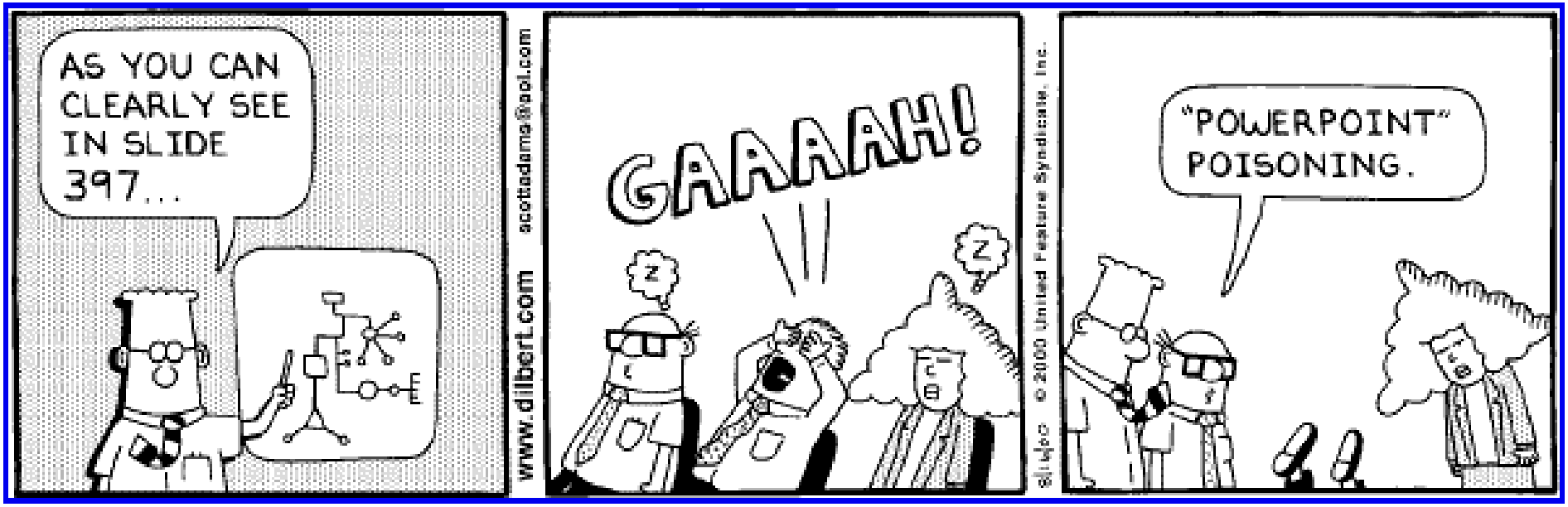
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