OpenTERRAworks GIS Tool Webinar:

Overview and Software Demonstration

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Athens, GA
July 17, 2013

Webinar Objectives

- Overview of OpenTERRAworks Design – 30 Minutes
- Discussion Period for Executive-Audience Feedback – 10 Minutes
- Video-Based Software Demos of Select Capabilities of OTW
  - 6 Short Videos – 35 Minutes
  - Discussion Period for Technical Audience Feedback – 15 Minutes
- Post-Webinar Discussion on Future Community Development

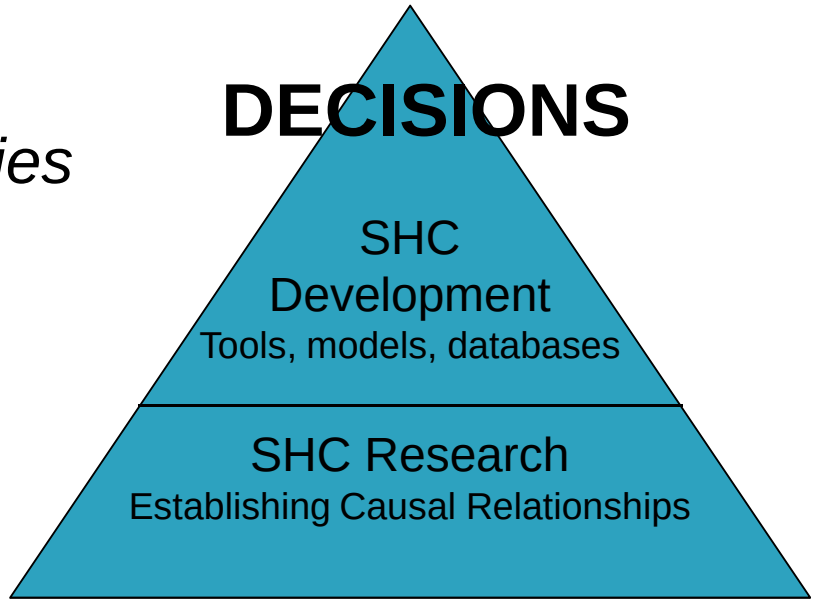
The findings and conclusions in this presentation have not been formally disseminated by the EPA and should not be construed to represent any Agency determination or policy.

ORD's Sustainable and Healthy Communities Research Program

SHCRP Vision:

... to inform and empower decision makers to effectively and equitably integrate human health, socio-economic, and ecological factors into their decisions in a way that fosters community sustainability.

i.e., actionable science for communities



Courtesy: NPD

SHCRP - Infusing science into decision analysis and decision-making……

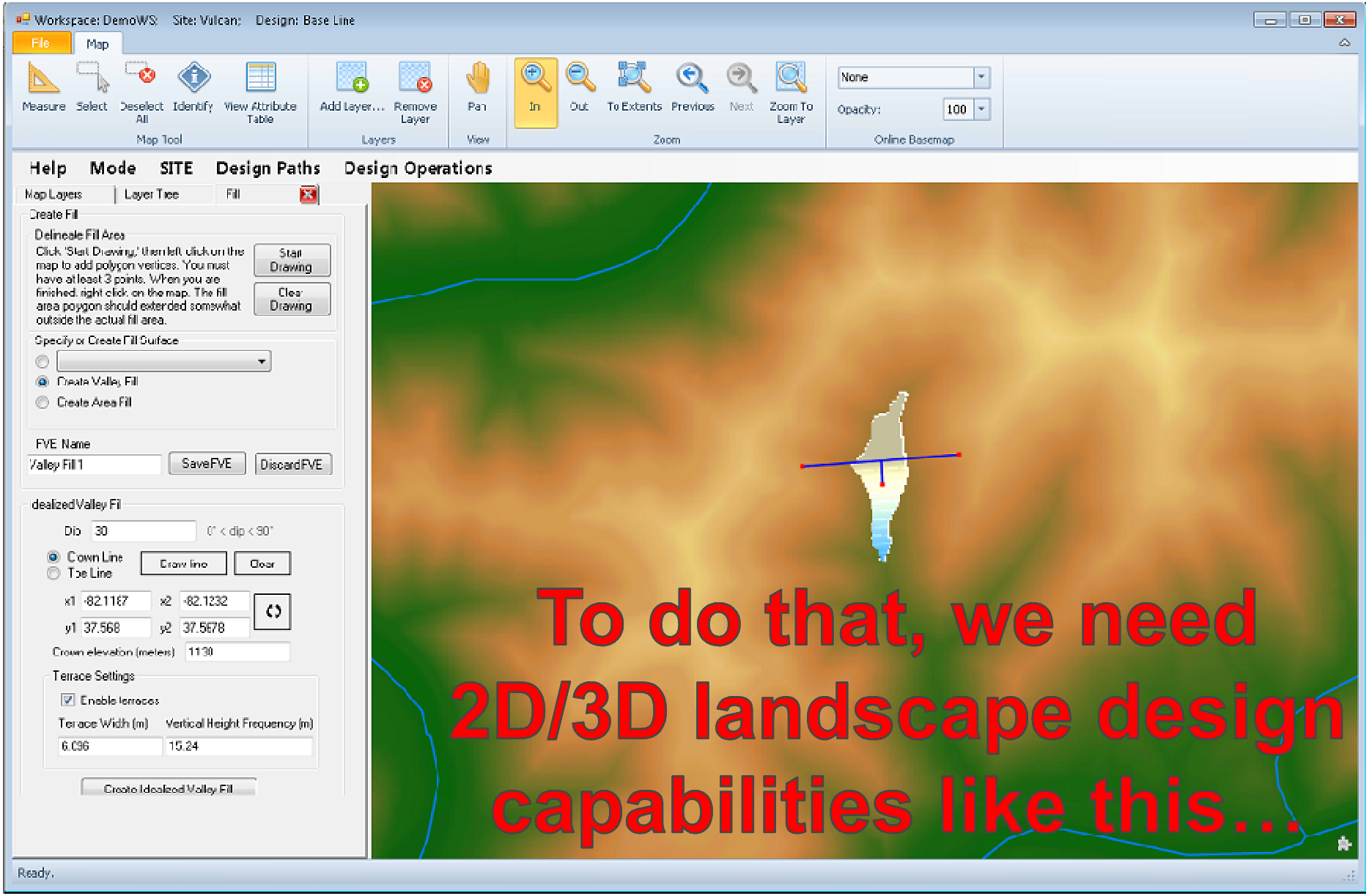
(SHC Task 2.1.5.2.4) **OpenTERRAworks**:
A 2D/3D Landscape Design Software System

Helping **MODEL THE FUTURE,** *and its alternatives,* **BEFORE IT HAPPENS**

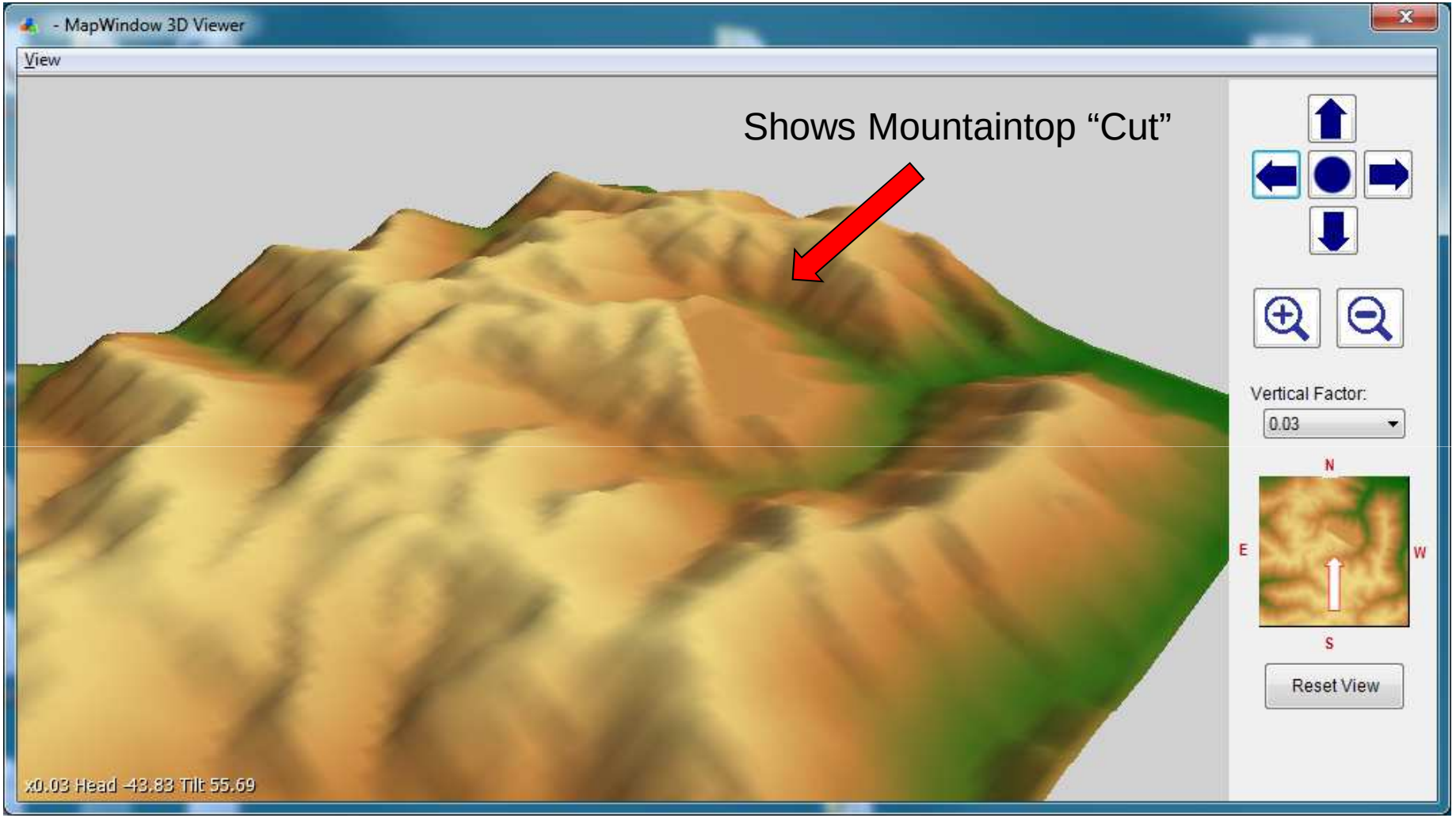
Example Problem: Coal Resource Extraction in Appalachia via Mountaintop Removal


The compelling problem we face:
By the time satellites see this, it's (way)
too late if it wasn't a good idea
(as well, never knowing if it was the best idea).
Solution: Get in front of
that problem.

OpenTERRAworks – Demo of Example Valley Fill Design



OpenTERRAworks: 3D View Mountaintop Removal (Post-Cut)



As well as pre-decision analysis of future perspectives like this…

In design and in decision-making, the problem is that the

FUTURE IS NOW.

OpenTERRAworks - A 2D/3D Landscape Design Tool

For those who can't wait for satellites to tell us the future.....

OpenTERRAworks - A 2D/3D Landscape Design Tool

An open, Dot-Spatial-based toolset supporting comparative baseline and futures scenario modeling.

EPA

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science in ACTION

BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS

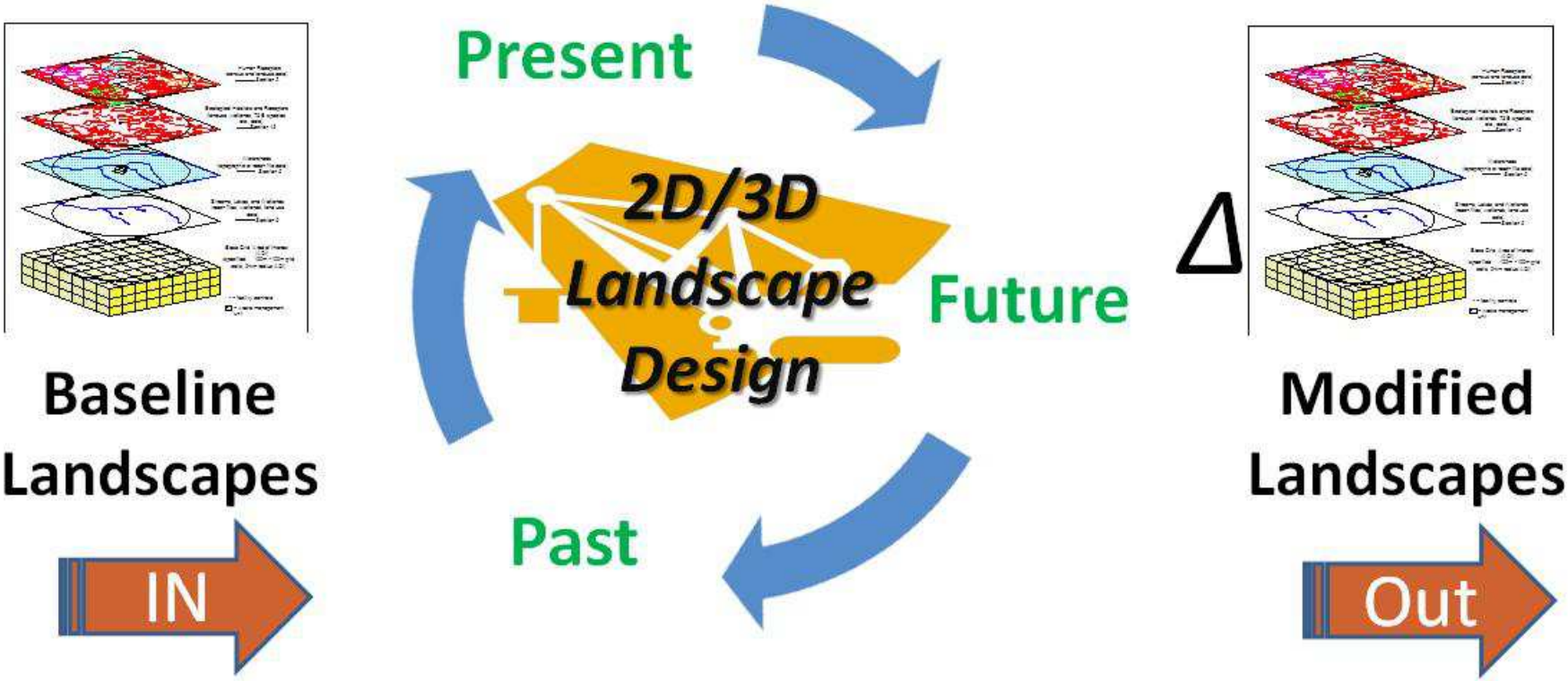
Safe and Healthy Communities Research Program

SHC Task 2.1.5.2.4

OpenTERRAworks GIS-Tool

Supporting Predictive Analysis of the Future Before it Happens

OpenTERRAworks



…supports a basic substitution pattern for model input data, providing "futures" datasets needed for downstream analytical frameworks.

The People Behind the OpenTERRAworks System

- Key Collaborators/Supporters
  - Region III
    RESERV funding (OTW Prototype)
  - Region IV
    RARE funding (OTW - Enhancements)
  - USGS
    IAG via Region III (Design consultation & review)
    - Hugh Bevans
    - Mark Kozar
    - Katherine Paybins
    - Terence Messinger
  - The many Inter-Agency Federal Panelists who assisted in peer review.

- Contractors
  - RTI International
    - Michael Lowry
    - Aaron Parks
    - Scott Guthrie
    - Stephen Beaulieu
  - University of Kentucky
    - Dr. Richard Warner (mine hydrologic and reclamation system design)
  - Penn State University
    - Dr. Antonio Nieto (mine design)
  - Brigham Young University
    - Dr. Daniel Ames (geospatial design).

- Key EPA Staff Support
  - Region III
    - Cynthia Stahl, Al Cimorelli, Janet Kremer, Kristopher DeNardi
  - Region IV
    - Amy Newbold, Daniel Holliman, Craig Hesterlee, Eric Somerville,
  - ORD (SHC Task 2.1.5.2.4)
    - Justin Babendreier – Task Lead
    - Including design consultation with key ORD staff from SHC Tasks 2.1.2.5 & 3.2.1.2: Kurt Wolfe, Mike Galvin, Rajbir Parmar, Lourdes Prieto, John Johnston, Roy Sidle.

- ORD RSL Staff Support
  - Ron Landy (Region III)
  - Tom Baugh (Region IV)

- Key Management Support
  - Randy Pomponio (Region III)
  - Bill Jenkins (Region III)
  - Jim Giattina (Region IV)

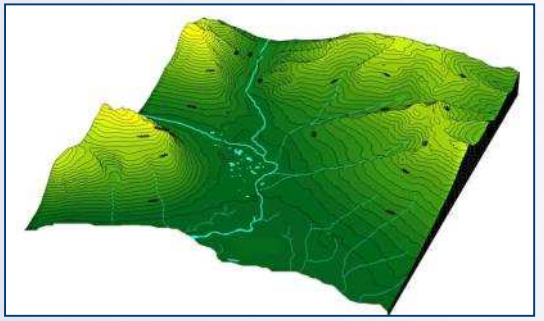
- Targeted Client-Base Supported
  - Regions III, IV (NEPA, CWA 402 and 404 permits)
  - Office of Water (CWA 402 and 404 permits)
  - Office of Federal Facilities (NEPA)

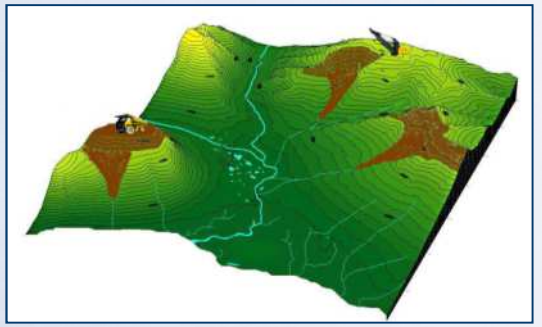
OpenTERRAworks Design Presentation

- Key objectives and conceptual overview
- Software operational modes
- Management of site design pathways
- Software process and data flow
- Corehole data management
- Terrain excavation operations
- Terrain fill operations
- Delineation of “Landscape Elements” of environmental concern (LEs)
- Land use data modification
- Soils data modification
- Hydrography modification
- Site and landscape data management (ensembles and modified landscapes)

Conceptual Design Goals of OTW

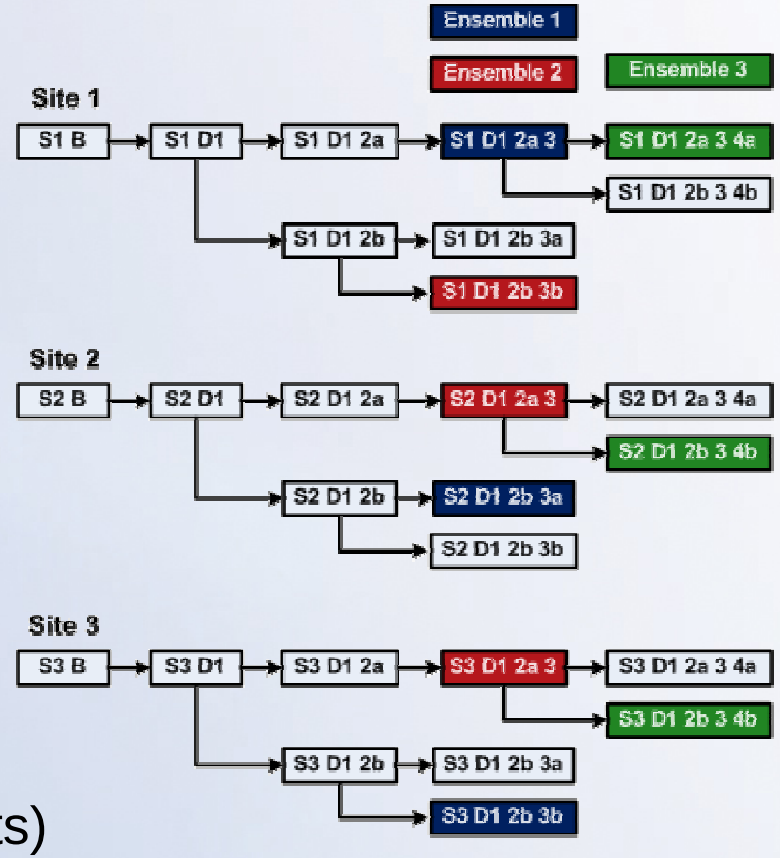
- Consume baseline datasets
  - Land use: NLCD
  - Soils: SSURGO and STATSGO
  - Terrain: DEMs (e.g., NED)
  - Hydrography: NHDPlus
  - Others (e.g., higher resolution, site specific)
- Represent terrain modifications
  - Terrain cut/fill
  - Modified hydrography, soils, and land use
- Produce modified site-scale datasets
- Produce larger-scale (HUC8) datasets
  - Integrate with unmodified areas
  - Include multiple sites (ensembles)
- Feed comparative analysis engines
  - USEPA's iemTechnologies
  - Other modeling/analytic platforms



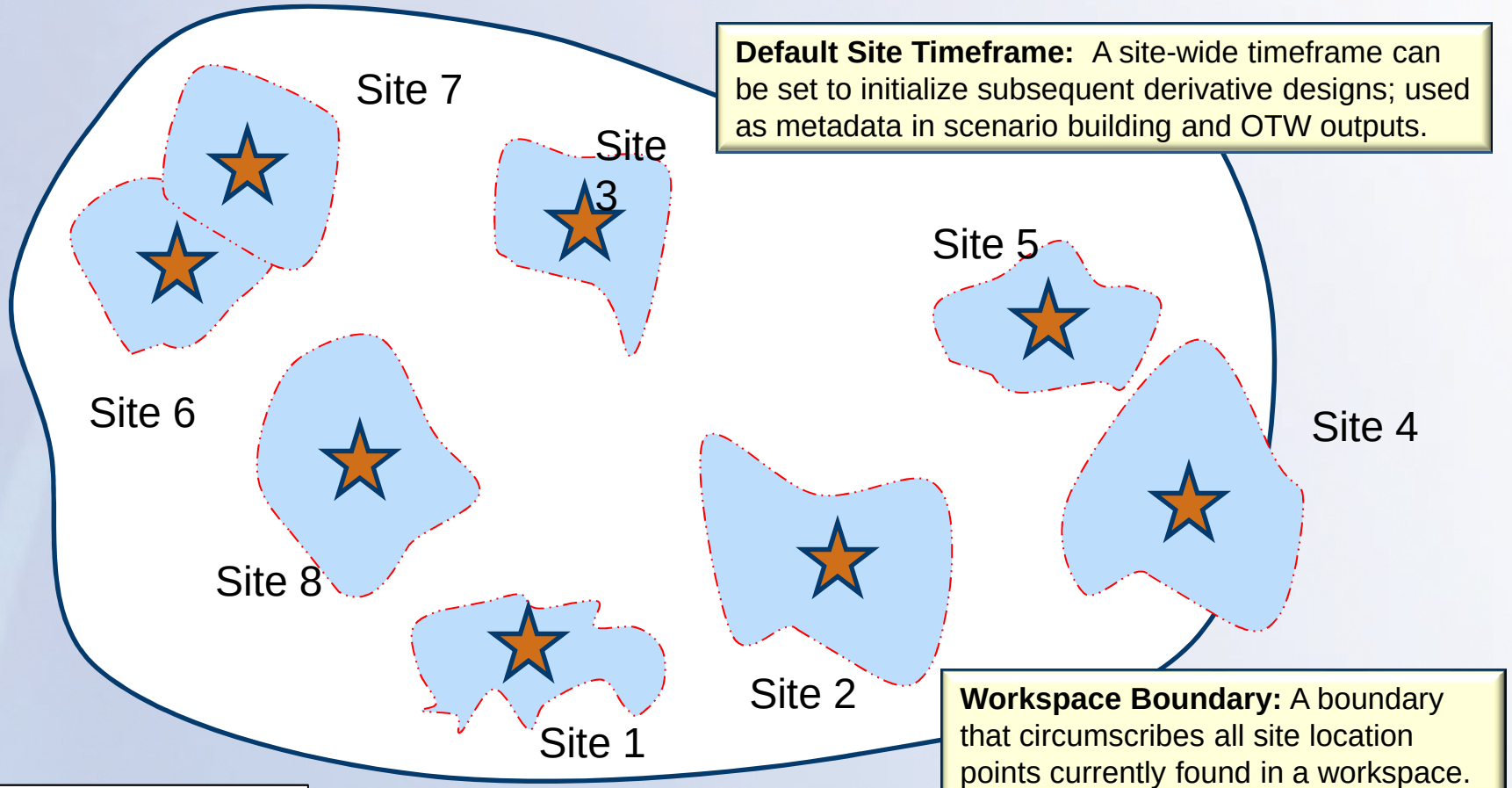


OTW Operational Modes and Site Design Path Management

- Workspace mode
  - Organize sites in workspace file environment
- Site mode
  - Import and modify site datasets
  - Manage design paths
  - Represent landscape changes
    - Perform excavation and fill operations
    - Modify land use, soils, and/or hydrography
- Ensemble mode
  - Create collections of two or more site designs (*w/ mutually exclusive site areas*)
  - Relevant to specific, common time frame
  - Aggregates site designs across space.
- Landscape mode (produce OTW outputs)
  - Create “landscape sets” (list of ensembles) for batch processing of multiple scenarios.
  - Produce modified landscape datasets.



Create and Manage “Site” Objects in an OTW Workspace



Default Site Timeframe: A site-wide timeframe can be set to initialize subsequent derivative designs; used as metadata in scenario building and OTW outputs.

Workspace Boundary: A boundary that circumscribes all site location points currently found in a workspace.

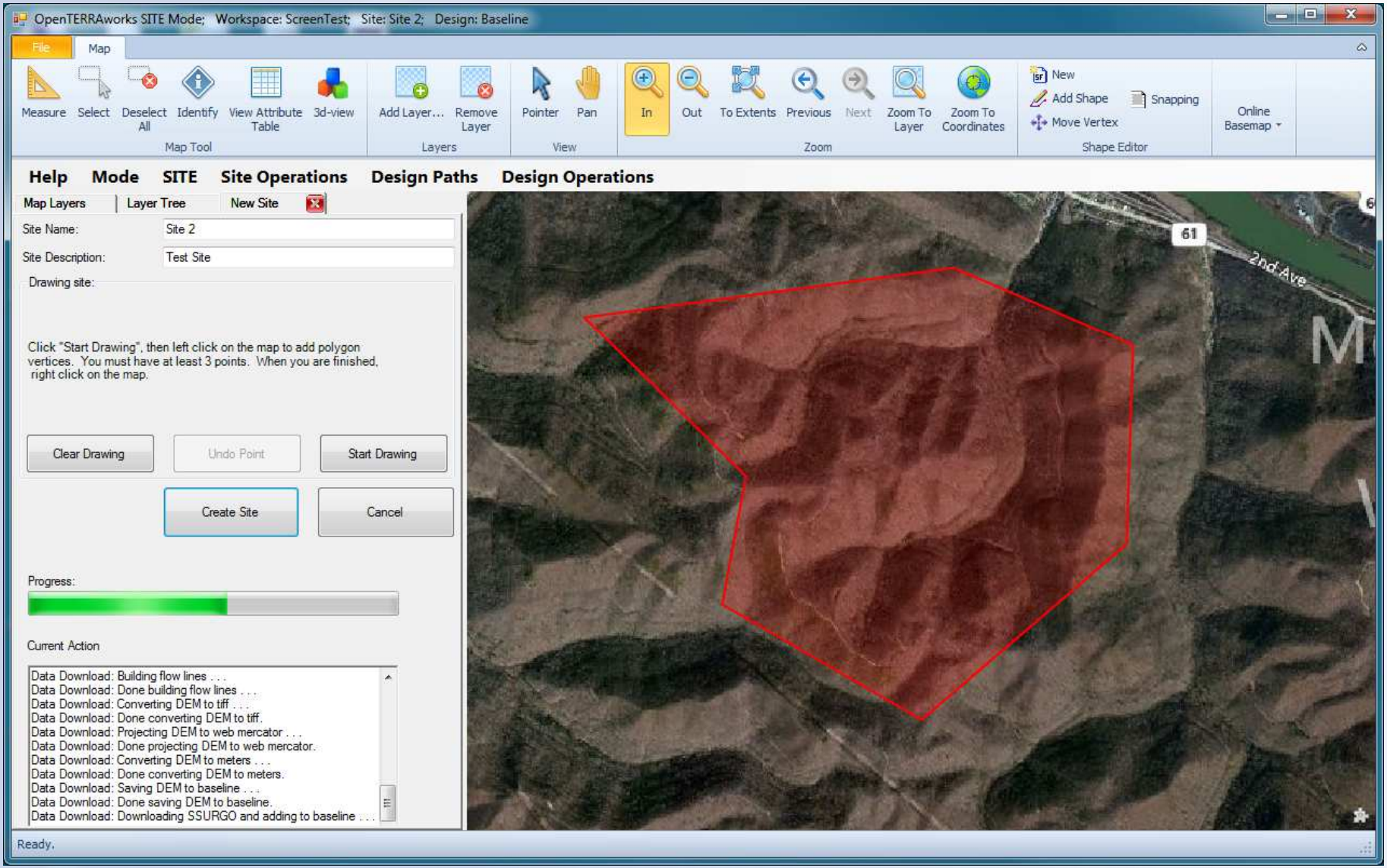
Site Area

Site Location Point

Workspace Boundary

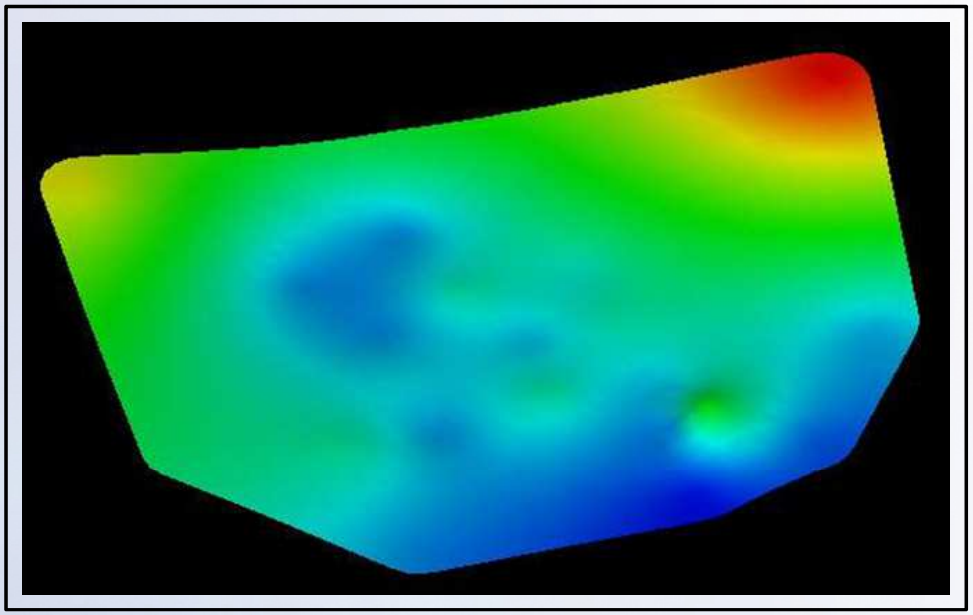
Site: In creation, a site polygon is first specified by the user to establish the expected scope of design modifications. Typically set to the smallest area needed to handle design paths anticipated.

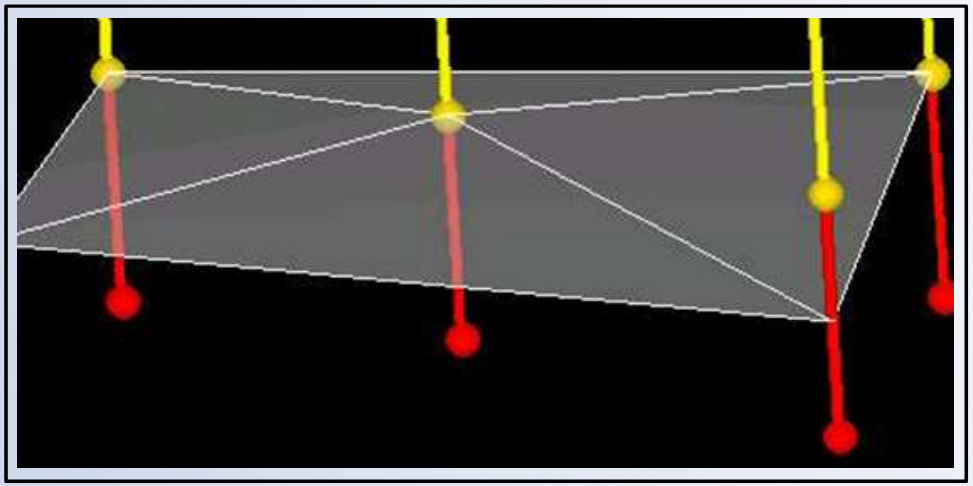
Create Site & Set the Initial Site Design Area



Corehole Data Management

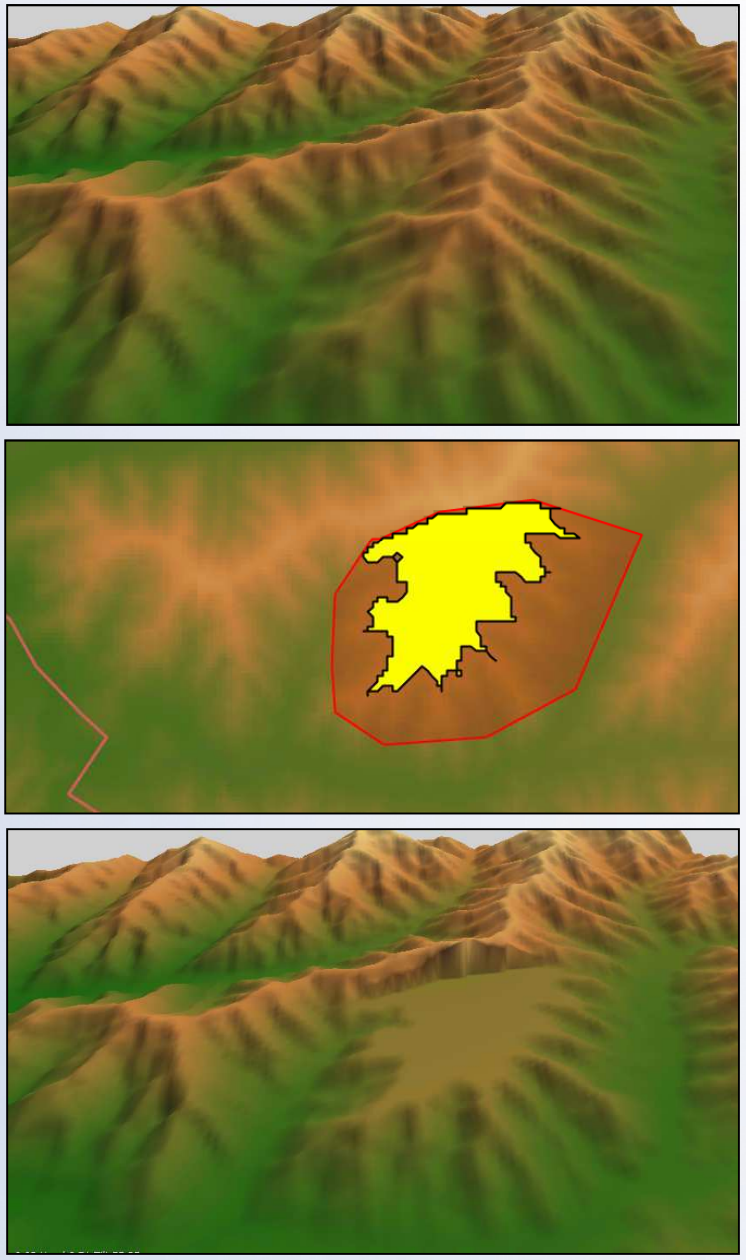
- Import, enter, and manage corehole data
  - Depths of geologic interfaces
  - Quality measurements (e.g., sulfide content)
- Interpolate surfaces
  - Top of shale
  - Top of coal
  - Distribution of selenium concentrations
- Surfaces used for terrain excavation and fill operations
- Can also import DEMs
  - Higher resolution than NED
  - Created externally





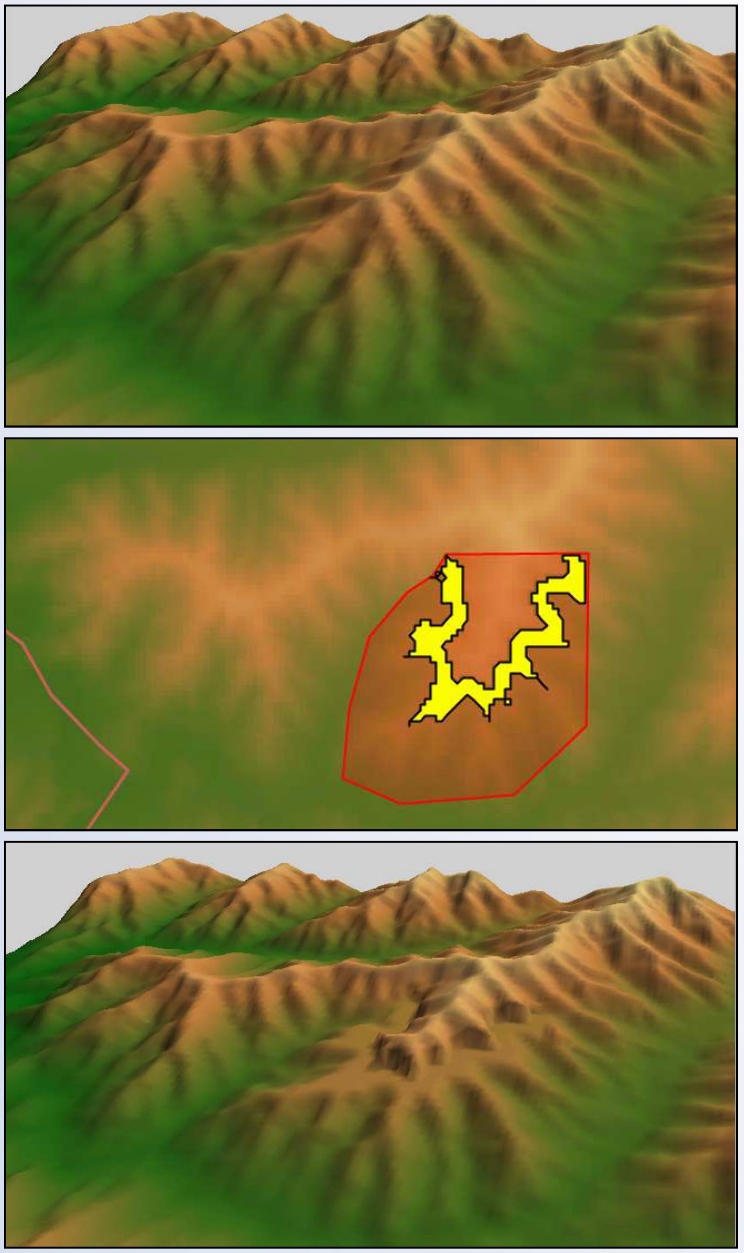
Terrain Excavation (Cut) Operations

- Required surfaces
  - Pre-excavation elevation surface
  - Cut elevation surface
- Cut operation
  - Calculate thickness (subtract cut elevation surface from pre-excavation surface)
  - Subtract thickness (where > 0) from pre-excavation elevations
- Yields an excavated volume element (EVE)
- Calculate volume (*in-situ* and *ex-situ*)
- Assign or calculate attributes (e.g., sulfur content, weighted average)
- Can be performed at any scale
  (subject to inherent limitations of DEM scale)



Specialized Cut Operation: Contour Mine

- Specify outer edge for contour mine cut
- Specify distance to excavate (bench width; e.g., 135 ft)
- System automates cut operation
- Future development for other contexts possible
  - Support assessment of other landscape modification activities (e.g., landfill construction, commercial development)
  - Open source platform allows third party development (e.g., add-ons).



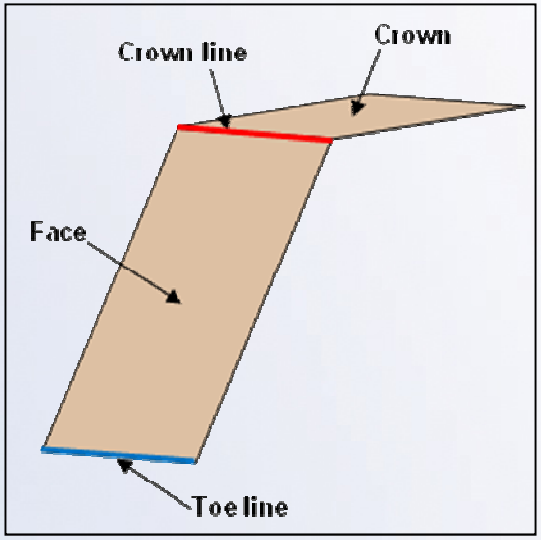
Post contour cut elevation surface

Terrain Fill Operations

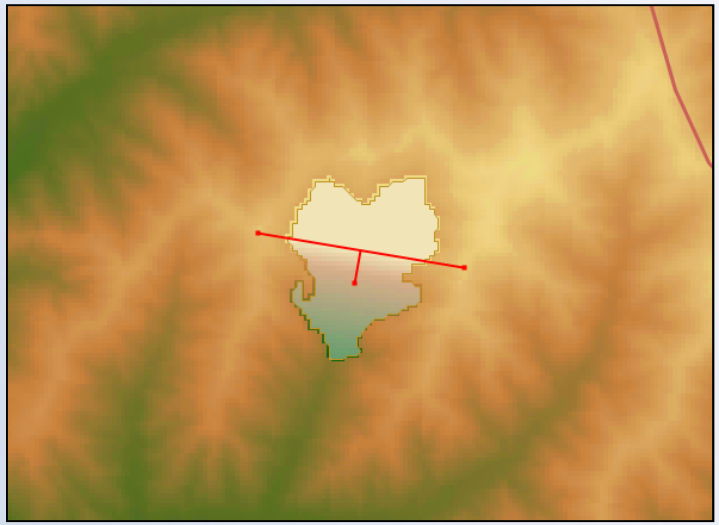
- Required surfaces
  - Pre-fill elevation surface
  - Fill elevation surface
- Fill operation
  - Calculate thickness (subtract pre-fill elevation surface from fill elevation surface)
  - Add thickness to pre-fill surface (where > 0)
- Yields fill volume element (FVE)
- Specify fill material(s) from one or more EVEs
- Calculate volume
- Assign or calculate attributes (e.g., volume weighted averages)
- AEC polygon automatically created
- Can be performed at any scale
  (subject to inherent limitations of DEM scale)

Specialized Fill Operation: Valley Fills

- Automated creation of fill elevation surface
- Specify
  - Crown line
  - Crown elevation
- Specify slope of face (2:1 typical)
- Prototype includes terraced faces
- Prototype does not provide *automated* layering or segregated disposal within fills
  - However, one can import externally created surfaces.



Idealized fill elevation surface



Delineated crown line with preview fill surface

Valley Fill: 3D Visualization

Before

After

Landscape Elements *of Concern* (LEs)

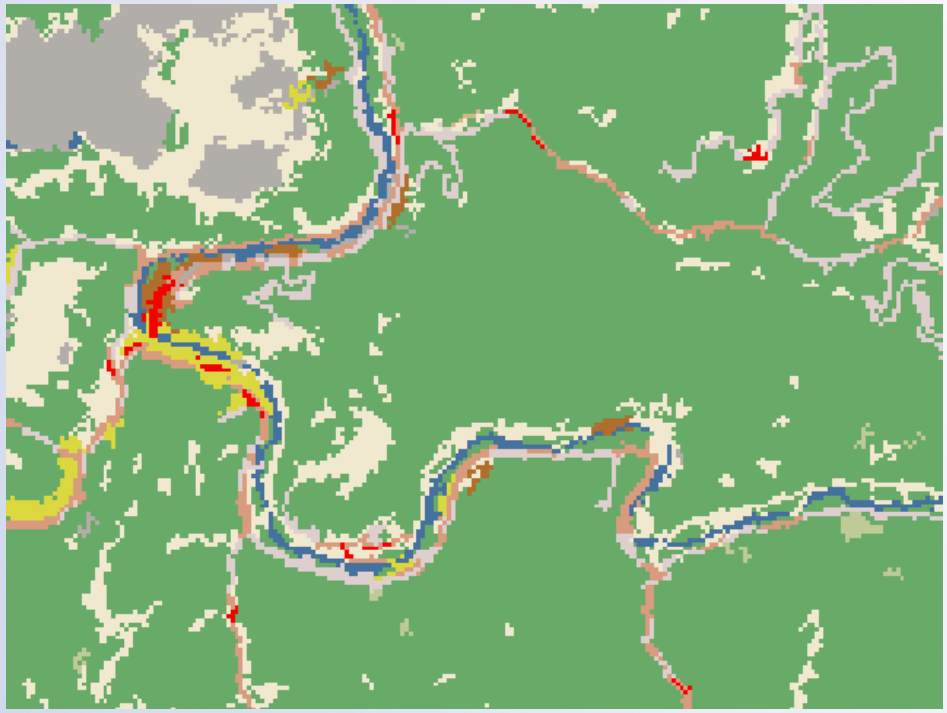
- Multiple LE classes (sources, source control, sensitive LEs)
- User delineated features of potential environ. concern.
  - points, lines, or polygons
- Fill area polygons created automatically as LE sources.
- Other examples
  - Impoundments
  - Erosion and drainage control features
  - Stockpiles
  - Coal processing facilities
- Attributes defined/added by user (class specific)

Valley fill and drainage pond

Coal processing waste impoundments

Land Use Data Modification

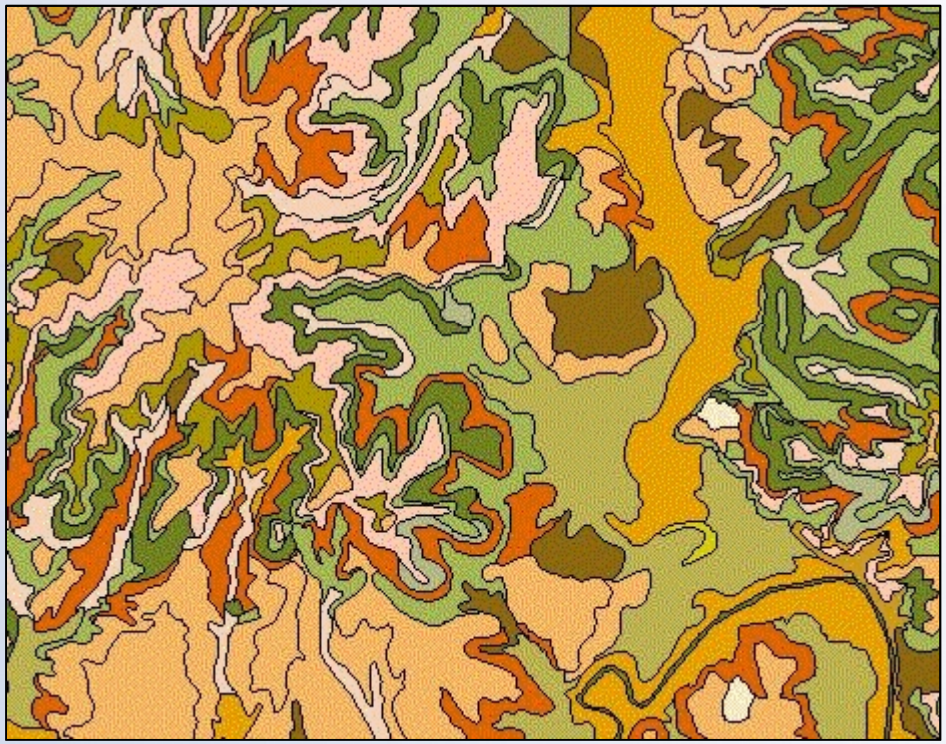
- Automated download of baseline dataset (NLCD)
- Discrete valued raster modification
  - Delineate modified polygonal areas
  - Assign modified land use class to raster (e.g., pre-mine forest → active mine impervious → post mine grassland → post reclamation forest)
- OTW can work with other discrete raster datasets
  - site specific, high resolution.



Example NLCD coverage

Soils Data Modification

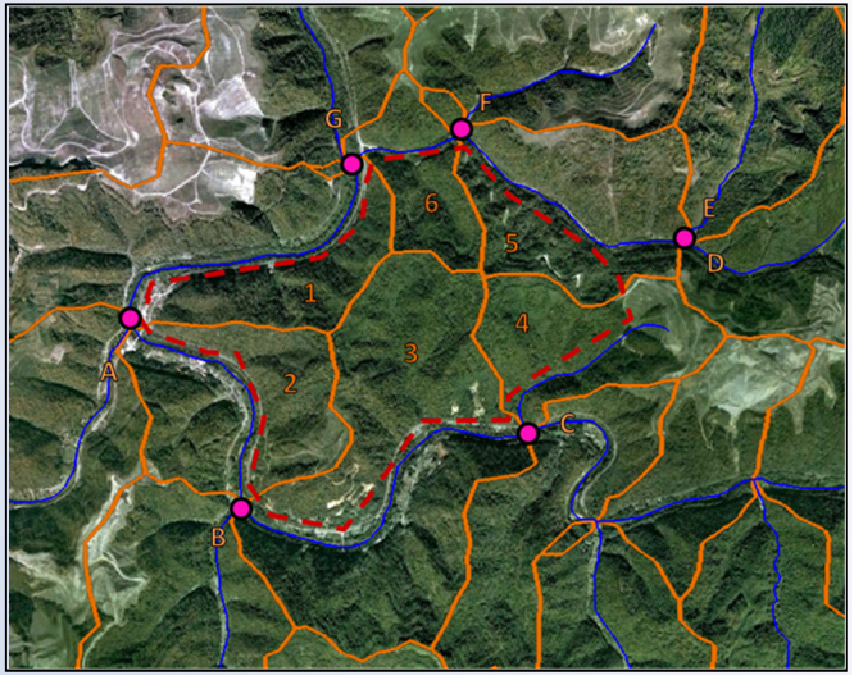
- Automated download of baseline datasets
  - SSURGO or STATSGO
- Polygon modification representing landscape change
  - Merge polygons
  - Split polygons
  - Delineate new polygons
- Assign attributes
  - Represent modified soil conditions (e.g., pre-mine forest loam → active mine open rock → post-mine disturbed topsoil)
  - Can create, save, and import named attribute sets
- OTW can work with other polygon layers (e.g., site-specific, high resolution soils)



Example SSURGO soil polygons

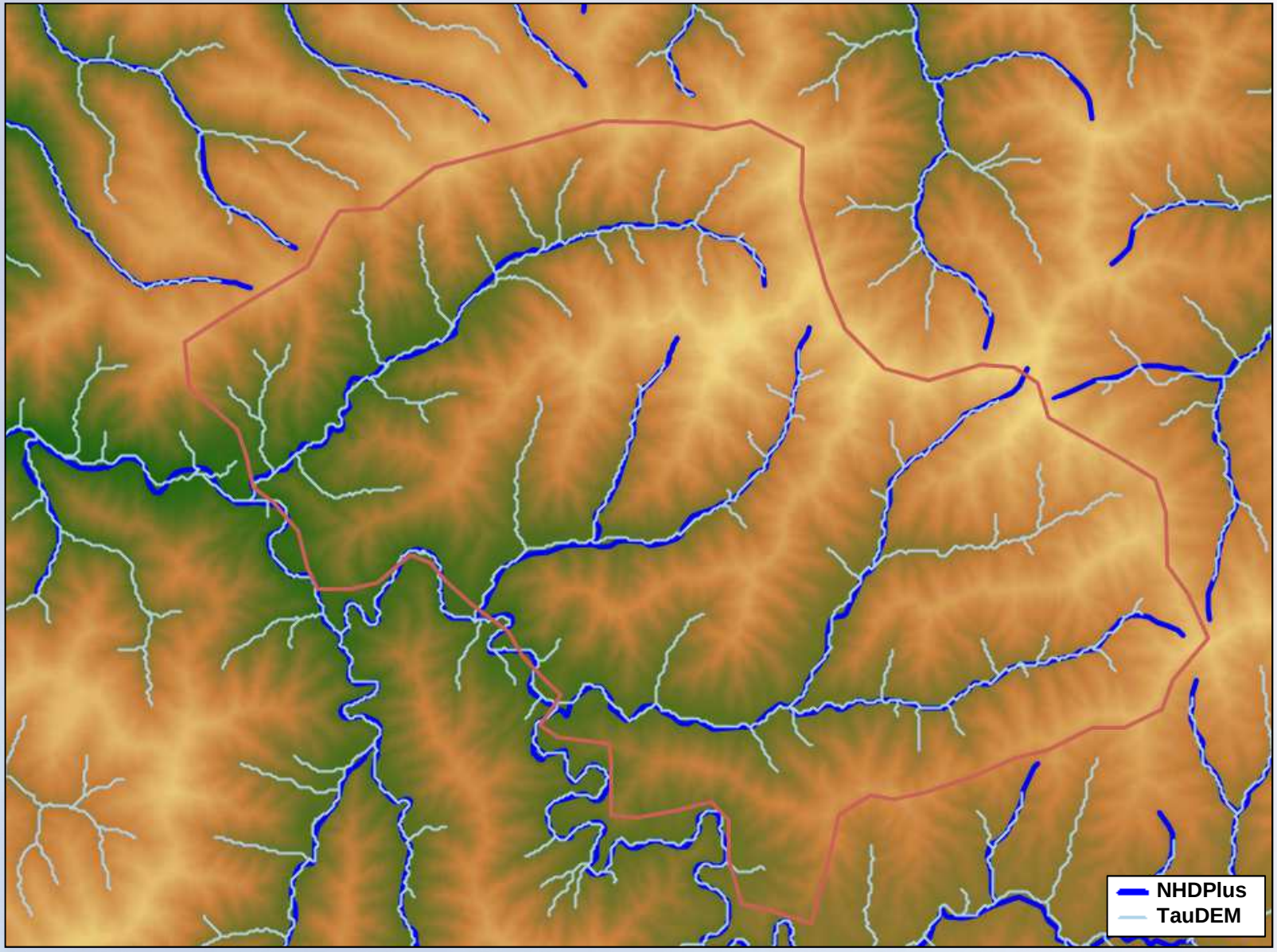
Hydrography Modification

- Automated download of NHDPlus
- Production of modified hydrography (optionally more detailed than NHDPlus)
  - Input: Modified terrain surface
  - Algorithm: TauDEM
  - Output: Modified streams and catchments
- User defined level of detail
  - Set via TauDEM threshold parameter
- Manual modification
  - Connect with unmodified NHDPlus network
  - Delete redundant flowlines
  - Add engineered drainage features (drainage channels, drainage ponds)
- Integrate modified hydrography with surrounding, unmodified NHDPlus
  - Integrity rules (e.g., match inlet and outlet points with unmodified NHDPlus)
  - Allow production of larger-scale datasets



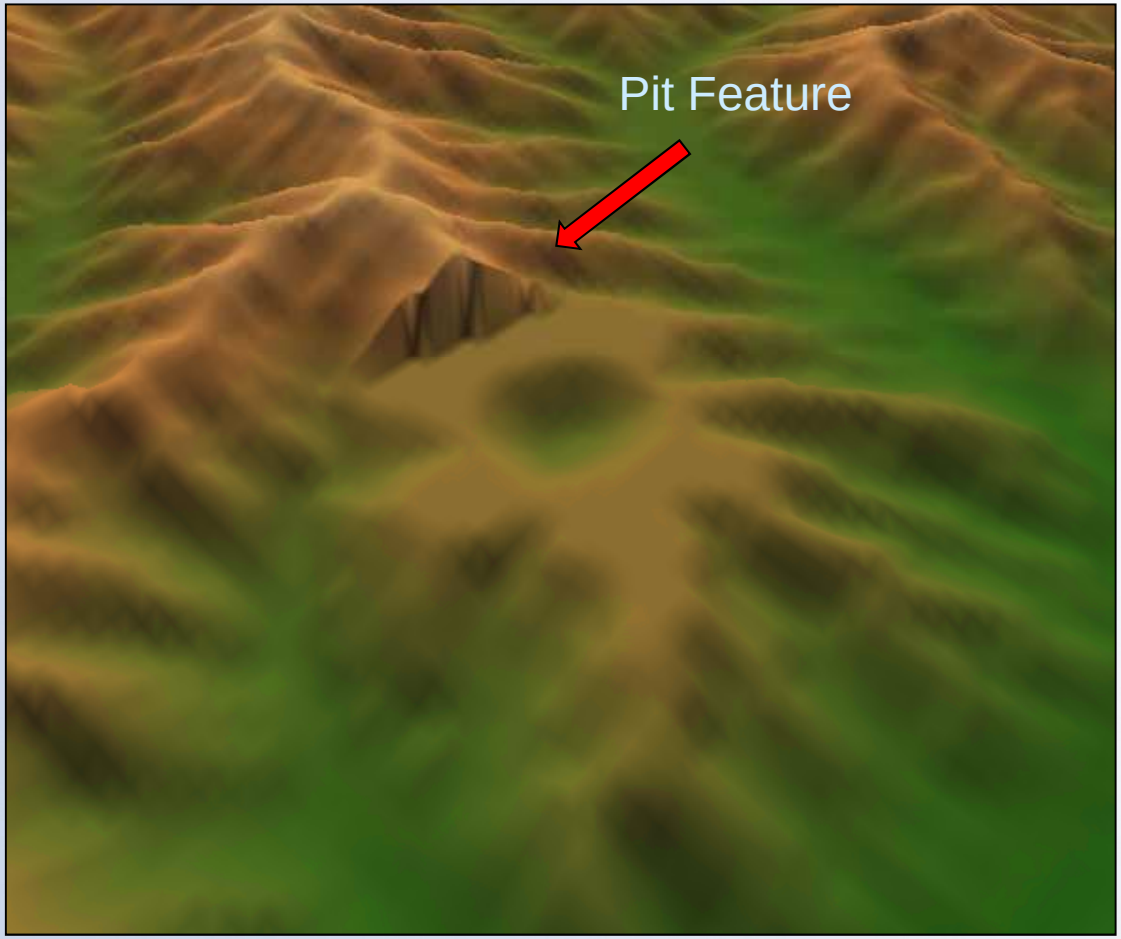
Catchments (orange), proposed mine area (dashed red), inlets and outlets (pink circles) between modified (numbered) and unmodified (lettered) catchments

Example NHDPlus versus TauDEM Hydrography

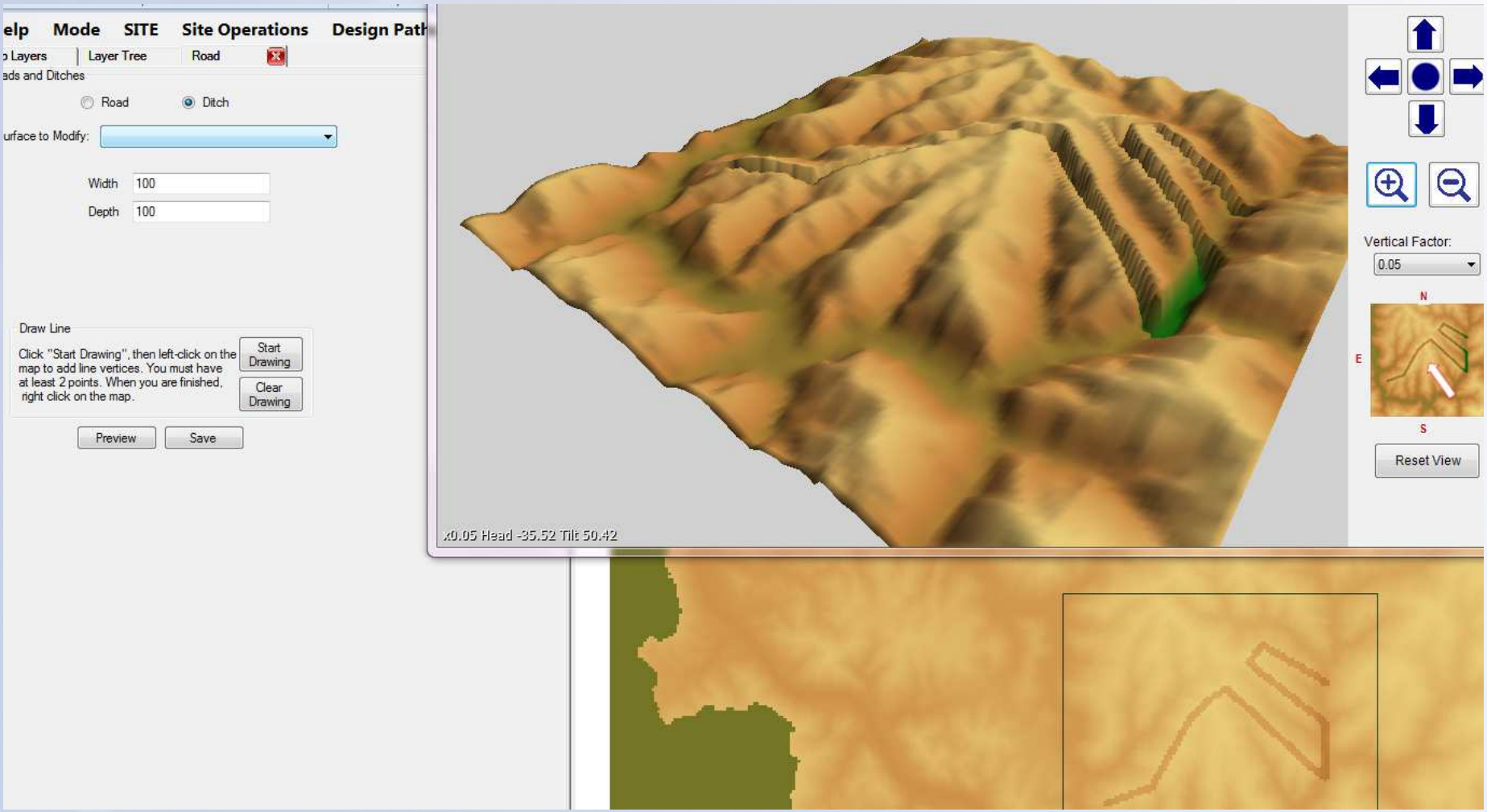


Specialized Cut Operation: Pits

- Delineate pit outline
- Specify
  - Side slope
  - Depth
- System generates modified DEM with excavated “pit”.

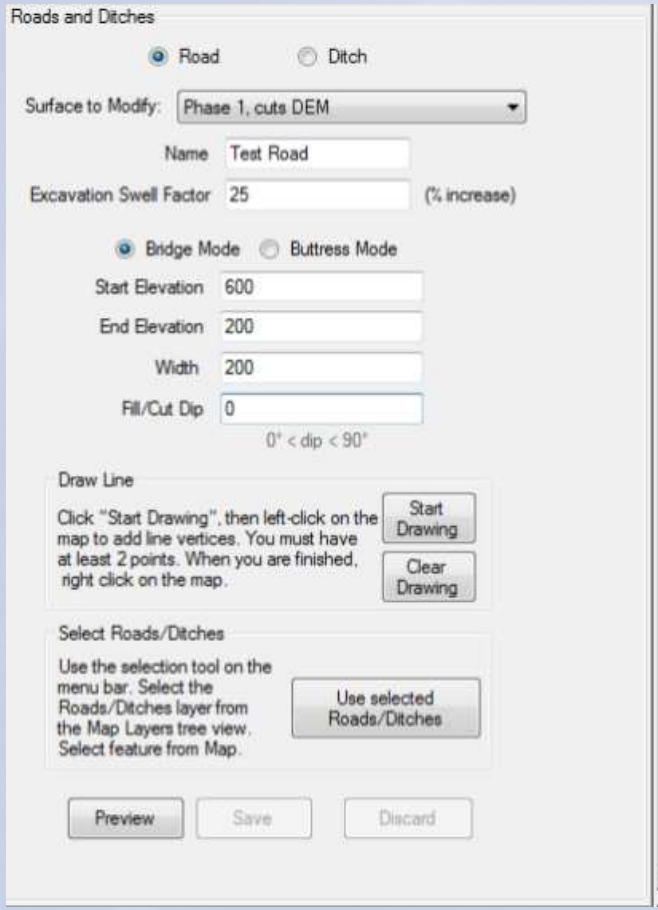


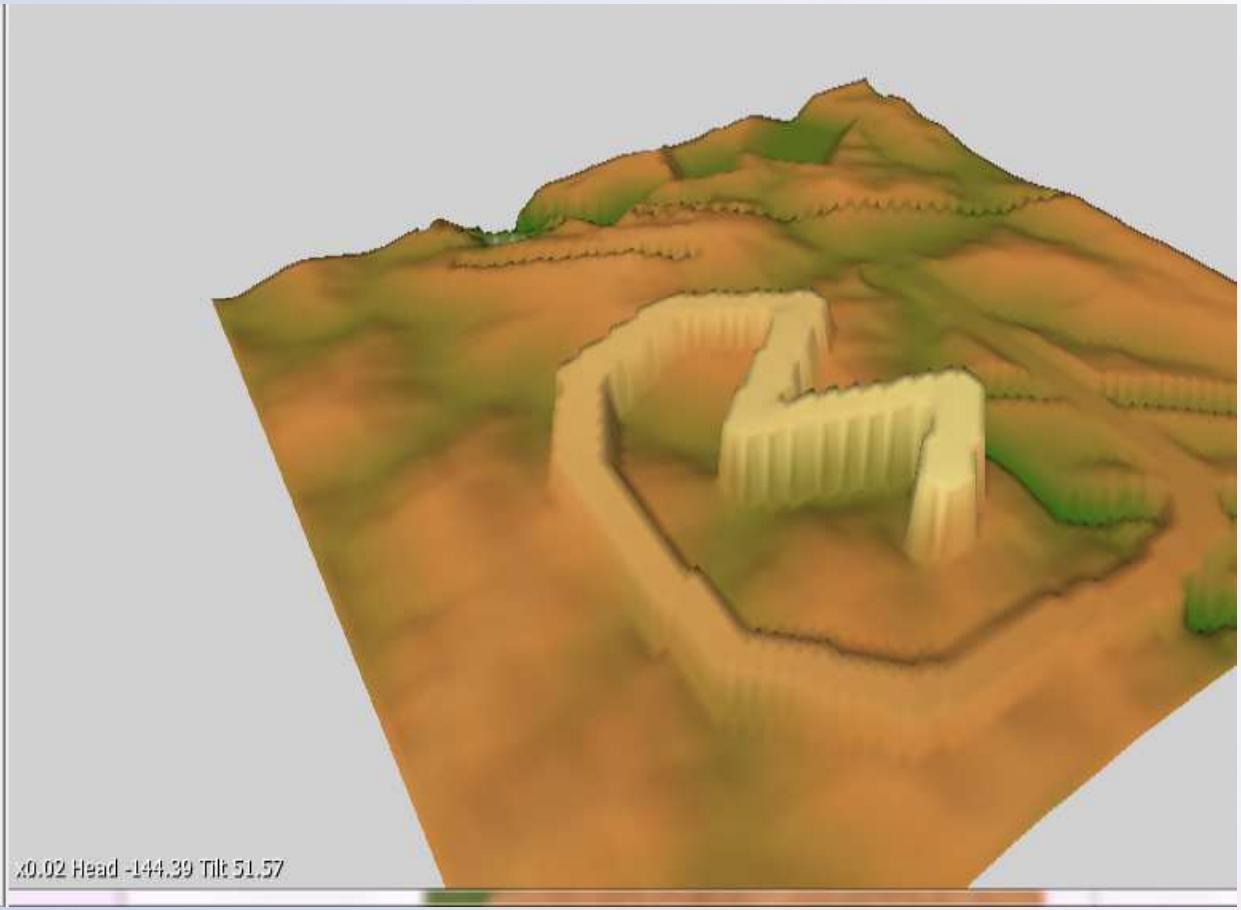
Specialized Cut Operations - Ditches



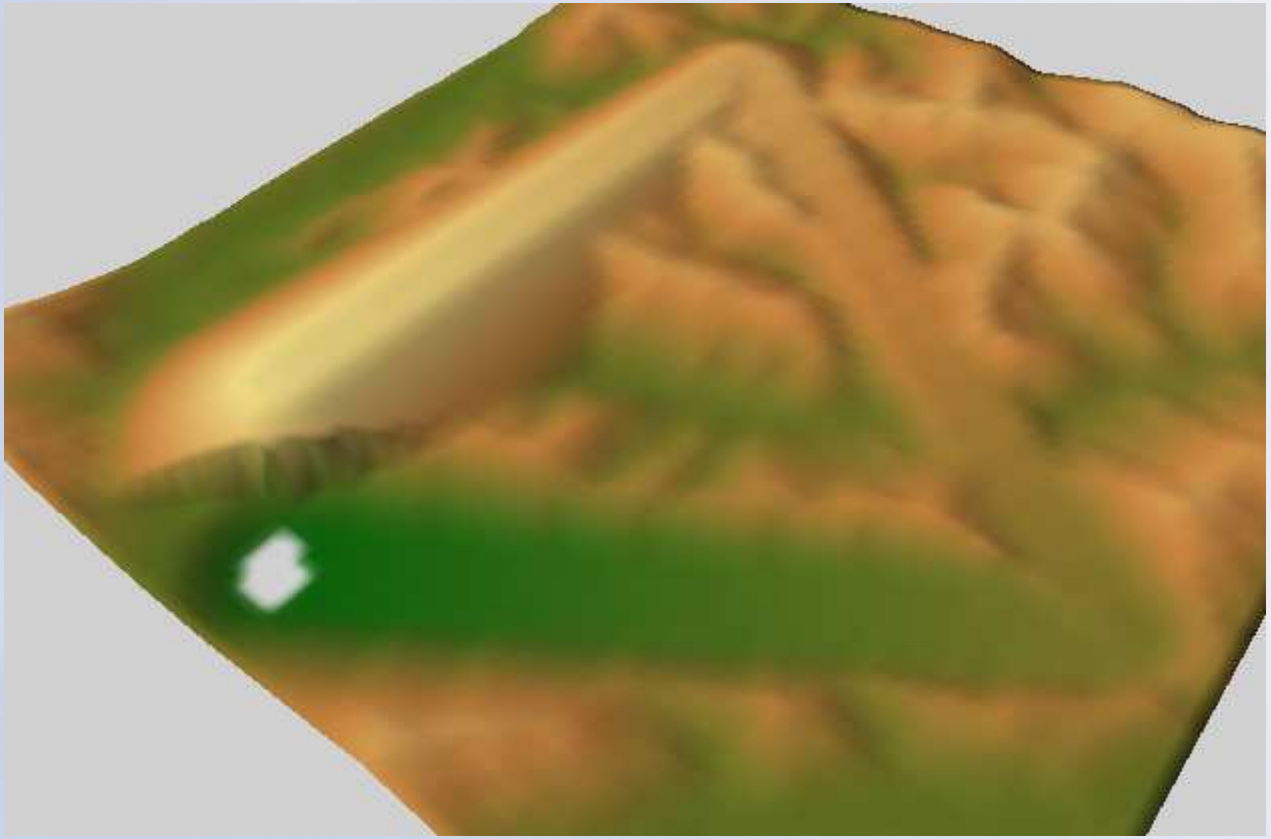
Specialized Cut/Fill Operations - Roads

Bridge Mode



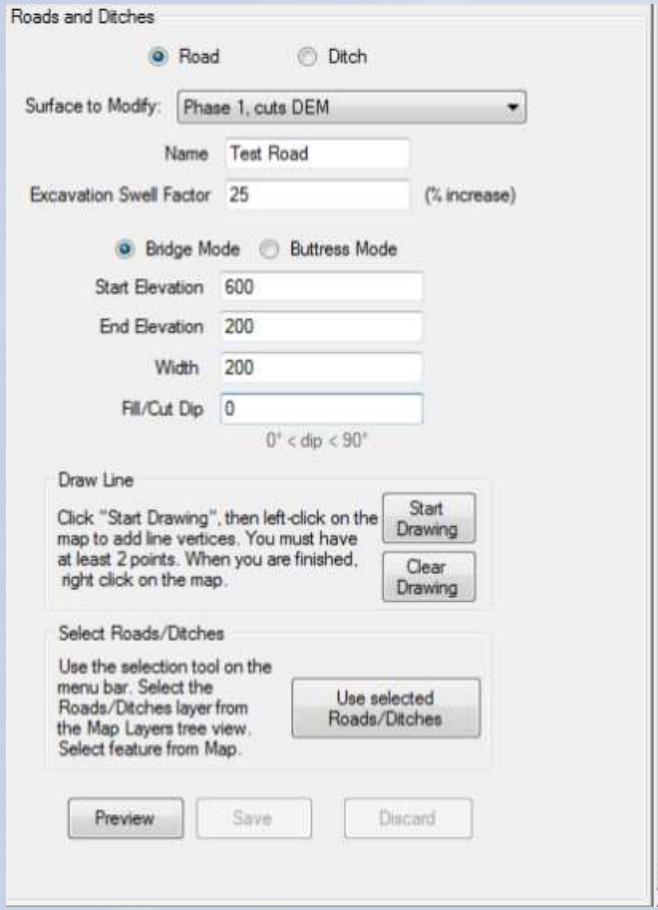


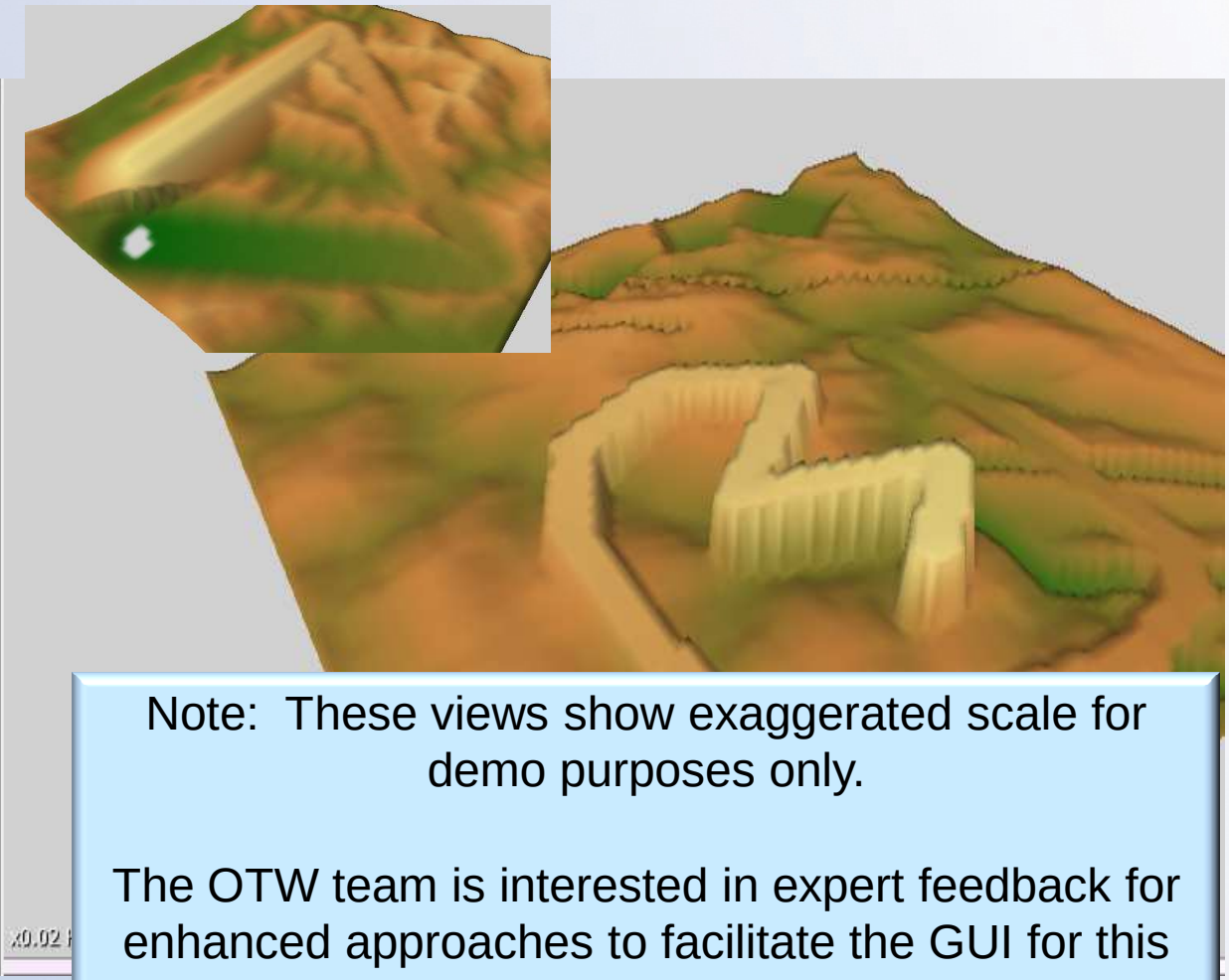
Specialized Cut/Fill Operations - Roads



Buttress Mode

Specialized Cut/Fill Operations - Roads



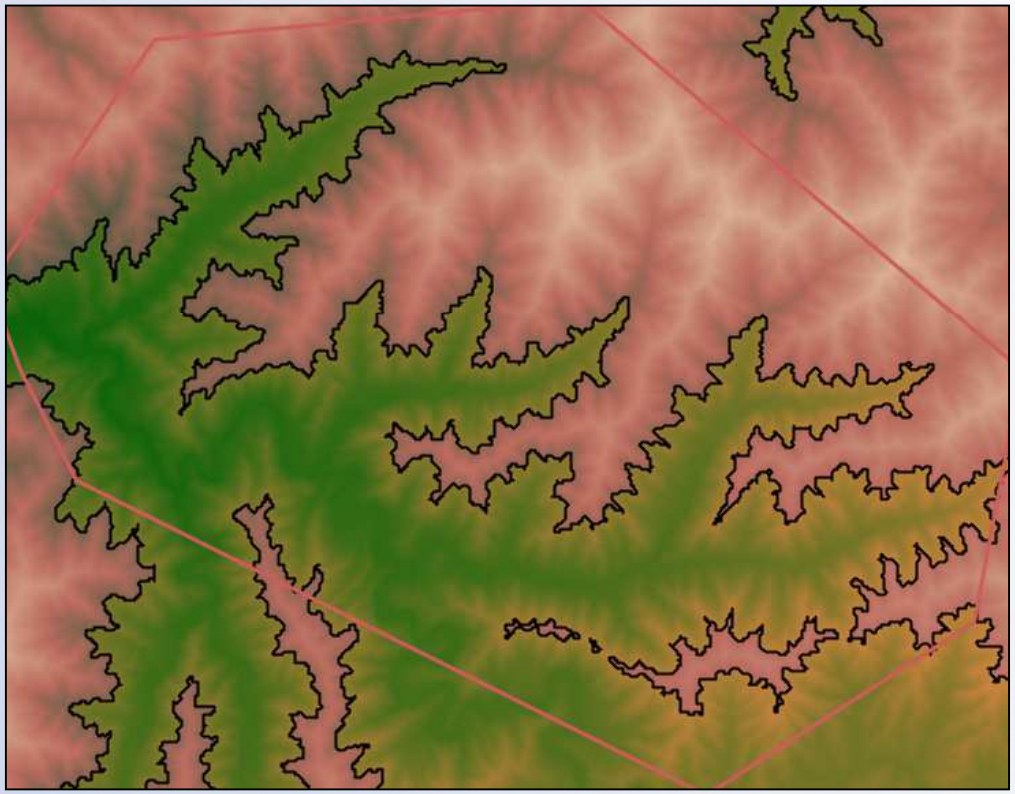


Note: These views show exaggerated scale for demo purposes only.

The OTW team is interested in expert feedback for enhanced approaches to facilitate the GUI for this set of standard, combined “cut & fill” operations.

Coal Seam Data Import and Erosion

- OTW can import external raster surfaces (e.g., top or bottom of target coal seam)
- Optional unit conversion (e.g., ft→m)
- “Geologic erosion” operation shows the intersection of geologic surface with topography.
- The black line shows coal seam outcrop (w/ “pink” as overburden).



Results of a geologic erosion operation showing the presence of the Middle War Eagle coal. The formation is absent where it has eroded. Data source: West Virginia Coal Bed Mapping Program

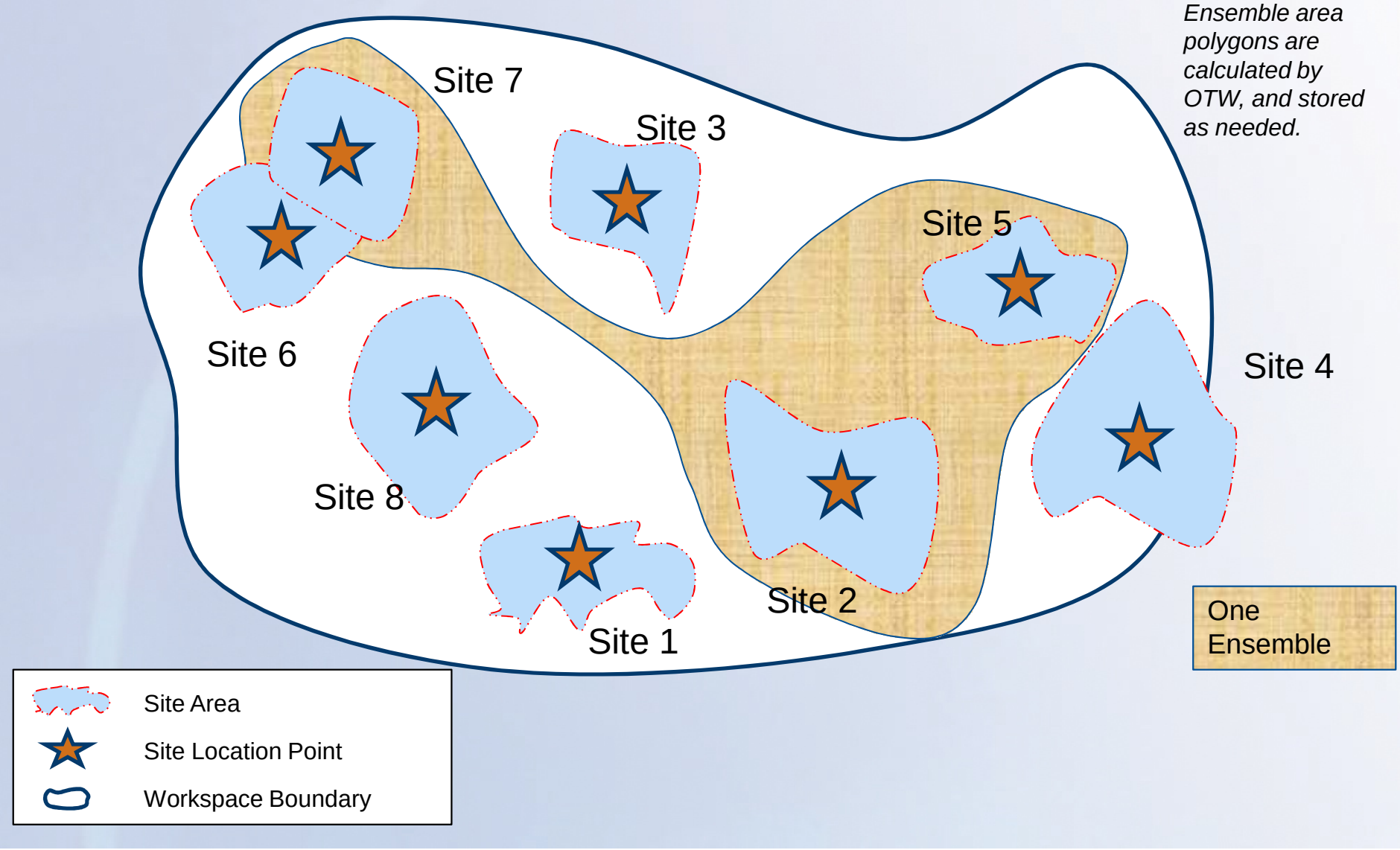
Ensembles and Modified Landscapes

- Ensemble: collection of site designs relevant to specific timeframe
  - Select a set of sites (with mutually exclusive areas)
  - Select design (i.e. branch/phase) representing each site in the ensemble.
  - Save, edit, copy, delete

- Landscape set: collection of ensembles
  - Defined prior to creating modified landscape datasets (i.e. OTW outputs)
  - Save, edit, copy delete
  - Supports batch processing for modified landscape dataset production

- Modified landscape datasets
  - HUC8 scale datasets (base design approach for I/O substitution pattern)
  - Integrate one or more modified sites with surrounding, unmodified data
  - Consumed by models for subsequent analysis (e.g., iemTechnologies
  - Supports assessment of cumulative impacts

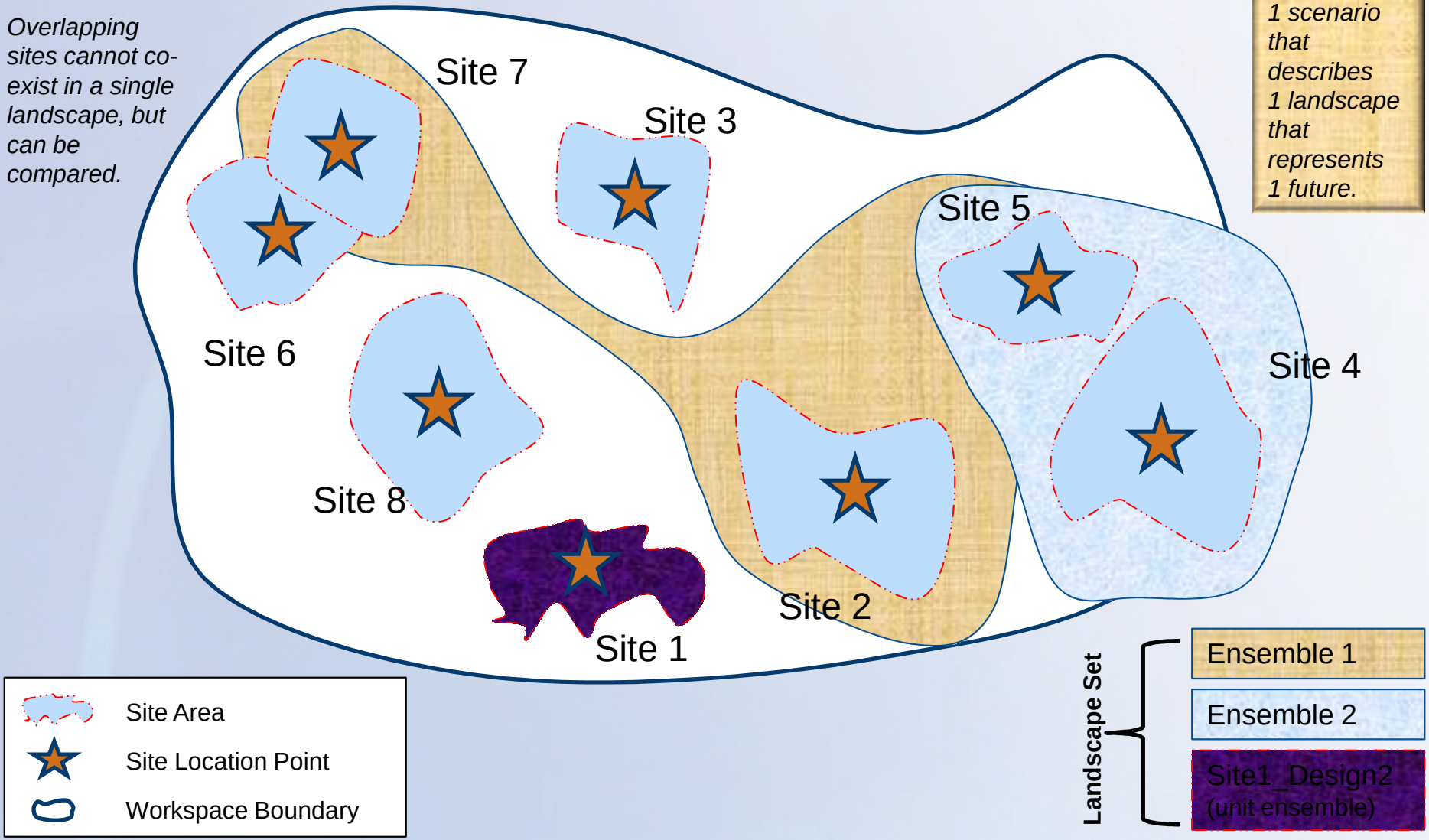
Create and Manage "Ensemble" Objects in a Workspace



Create and Manage "LandscapeSet" Objects in a Workspace

Overlapping sites cannot co-exist in a single landscape, but can be compared.

1 ensemble is 1 scenario that describes 1 landscape that represents 1 future.



OTW Independent Peer Review Process

- Selection process
  - Areas of required technical expertise identified by EPA
  - Candidates identified (publications, research interest, background)
  - Interviews, availability
  - Documented in memorandum
- Three peer reviewers from academia and industry (118 yrs coll. experience)
  - Mr. Steve Gardner, coal mining industry (CEO of ECSI)
  - Dr. John Quaranta, academia (West Virginia University)
  - Dr. Lee Saperstein, academia (Missouri S&T, emeritus)
- Four assessment areas specifically requested through charge questions
  - Core data layers
  - Cut and fill design algorithms
  - Areas of environmental concern (“AECs” later changed to “LEs” per review)
  - Hydrologic and cumulative impacts
- Reviews summarized in Sep. 25, 2012 memorandum (provided to additional Federal Panel of peer reviewers)
  - Comments organized into fourteen themes
  - Prepared preliminary responses for consideration by Federal Panel (Sep. 27. 2012)
- Conducted Federal Panel review; both reviews led to a final pre-build design.

Peer Review Comment Themes

1. Intended user community and application scope
2. Geology and rock quality data management
3. Drainage and erosion controls, BMPs
4. Hydrography and ridge lines
5. Material excavation, handling, and fill approaches (including soils)
6. Integration with detailed mine design software
7. Geomorphic/natural landform design
8. Appropriateness of core data layers
9. Management of alternative site design paths
10. Geotechnical assessment
11. Cumulative impacts
12. Issues with the scale of assessment
13. Other comments
14. Editorial comments

OpenTERRAworks Design - Key Points:

- OTW is not a model, instead, it helps modelers develop the inputs needed for modeling systems and other analytical frameworks.
- OTW can handle multiple scales and non-default data sets provided by users (e.g., LIDAR, import 3rd party designs, etc.)
- OTW can import and work with alternative datasets as long as they conform to the required data structures:
  - floating point raster for terrain elevations; discrete-valued raster for land use; and continuous polygon for soils.
- OTW is not just for mining analysis.
  - The tool is seen to easily serve 2D/3D design needs for golf-course or airport "siting" evaluation, as well as post-event analysis of earthquake or volcanic eruptions, etc., etc..
- "Designed in", but not yet fully implemented, expanded "2D" change scenario modeling is being added right now (RARE/R4).
- A “source term module“ for HF is within easy reach, allowing “auto” creation of associated roads and “cement pads” at a typical site.
- An OTW "module" is also envisioned for retrospective analysis.

Executive-Audience Q&A

Software Demos of Select Capabilities of OTW

OTW Help System Video #1

- Introduction to OpenTERRAworks
- OTW Workspace Management

Software Demos of Select Capabilities of OTW

OTW Help System Video #2

- Creating a New Site Design
- Site Operations
- Working with Design Paths

Software Demos of Select Capabilities of OTW

OTW Help System Video #3

- Site Operations: Importing Geology

Software Demos of Select Capabilities of OTW

OTW Help System Video #4

- Design Operations: Cuts

Software Demos of Select Capabilities of OTW

OTW Help System Video #5

- Design Operations: Fills

Software Demos of Select Capabilities of OTW

OTW Help System Video #6

- **Design Operations: Working With OTW's Materials Manager**

Technical-Audience Q&A

Future Community Development

An Open Discussion Forum

- Next Steps – Development Team
- External Beta Testing