

# Interactive Terrain Shaping

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### Preface

We begin this introduction to *Interactive Terrain Shaping* with the descriptions of new commands. The primary goal of this effort is to provide a holistic approach to terrain shaping, that allows users to go from concept to completion using the same model. The intent is to facilitate the development of comprehensive grading plans that can be easily tuned through the project cycle.

To make the project structure obvious and easy to manage, we have built a rich, expressive set of general-purpose components and operations whose main characteristics are flexibility, versatility and ease of use. The simple components can be combined and assembled into more complex components, representing pre-implemented pieces of design, ready to be integrated into the terrain.

We are introducing direct 3D model interaction in this new approach to allow users to optimize their designs in-canvas with intuitive interaction and dynamic feedback. We are also introducing design by flow grade in this approach. The flow grade is measured along the gradient of the surface, and is more suitable for designing parking lots and landfills. Flow grade allows the specification of maximum allowable grade which may be dictated by soil quality, design standards and ADA guidelines. Designing by flow grade and direction allows more control on drainage pattern, as demonstrated in tutorial videos.

Finally, we offer insight into the known limitations of the current model, which we hope to address before placing the final deliverable into the hands of our aspiring users.

### Commands

The following commands have been categorized into **Custom**, **Building Blocks**, and **Contextual** commands. Please refer to the [TUTORIAL 0 – INTRODUCTION](#) tutorial video to get a quick overview of the concept and workflow.

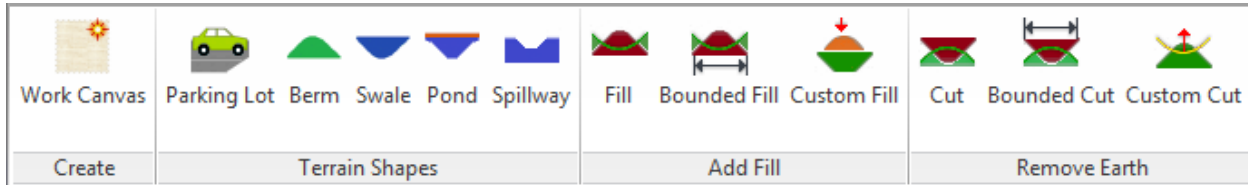
The **Custom** commands contain creation and modification operations that modify the finished ground directly. These commands can further be categorized into simple cut and fill operations and enhanced terrain shaping operations. The enhanced terrain shaping operations are pre-canned operations that apply a collective sequence of operations to shape the terrain in ways that directly map to the site development needs. These commands should serve as a starting point to new users and hence we recommend getting some hands-on experience with them before working with the building blocks. The introductory tutorial videos demonstrate using these commands to build enhanced terrain shapes such as ponds, parking lots, swales and berms. Each pre-canned command concludes with a list of primitive operations, which happen silently behind the scene.

All commands categorized as **Building Blocks** are targeted at advanced users who can work directly with the primitive elements. The advanced tutorial videos demonstrate workflows that build custom terrain shapes using primitive elements. These videos are very compelling and offer new insight into the power and flexibility of the model. We recommend using this videos as a reference for understanding how to use the design elements to build complex models.

Below is a complete list of commands to create a work canvas and use it to shape the terrain interactively.

## Custom Commands

These commands are available on the first four ribbon tabs.



### ***Tab: Create***

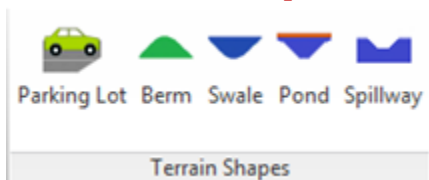
#### ***Create Work Canvas (AeccCreateTerrainShaper)***

Creates a work canvas (also called grading grid) from selected tin surface representing the existing ground and feature line representing the site boundary. The resulting grid will be used to shape the terrain. It mirrors the existing surface within the extents of the specified boundary. As operations are added, the canvas will get modified automatically and present the “finished ground”.

#### **Tips:**

- The selected boundary can be of any shape but the grid will be rectangular. Thus, the site will be bounded by the rectangular extents (in plan) of the selected boundary.
- Editing the site boundary would cause the entire model to get updated, which may be slow. We don't recommend moving or re-positioning the boundary once the grading grid has been created.

### ***Tab: Terrain Shapes***



#### ***Create Parking Lot (AeccCreateParkingLot)***

Adds a parking lot to the canvas by draping a footprint on the specified plane and grading it outside to finished grid with specified cut and fill grades.

#### ***Parameters:***

**Boundary:** Closed feature line that will serve as the boundary of the parking lot.

**Key point:** Fixed 3D point in space through which the top interior plane of parking lot must pass.

**Flow direction:** The direction in plan along the path of steepest slope of interior plane.

**Flow grade:** The grade (in %) along the flow direction of interior plane.

*Fill grade:* The flow grade (in %) at which the footprint is graded out in fill.

*Cut grade:* The flow grade (in %) at which the footprint is graded out in cut.

### *Behind the scene operations:*

- Creates a planar grid with specified parameters.
- Drapes the footprint on planar grid.
- Creates a fill grid with specified parameters.
- Combines it with finished grid using *Top Envelope* operation.
- Creates a cut grid with specified parameters.
- Combines it with finished grid using *Bottom Envelope* operation.

### **Tips:**

- To balance cut and fill volumes, select a point at the center of area bounded by closed footprint when specifying the key point of interior plane.
- The flow grade of top plane should be smaller than outside cut or fill grades.
- To add another flow plane to the interior geometry on which the boundary is draped, use **Grade Break: Crown** (*AeccCreateGradeBreakMin*) to replace the plane with a more complex shape (resembling crown) that uses a combination of planes with different flow directions to control drainage.

### **Create Berm** (*AeccCreateBerm*)

Adds a rounded embankment to the canvas.

#### *Parameters:*

*Feature line:* Baseline from which berm geometry is projected.

*Radius:* Controls the radius of the rounded top. The radius can be zero for an angular berm.

*Fill grade:* Controls the grade (in %) at which the footprint is graded in fill.

### *Behind the scene operations:*

- Creates a fill grid.
- Combines it with finished grid using *Bottom Envelope* operation.

**Tip:** The footprint must lie above the existing surface, otherwise the berm would not show up in the finished grid.

### **Create Swale** (*AeccCreateSwale*)

Adds a rounded swale to the canvas.

#### *Parameters:*

## Interactive Terrain Shaping

*Feature line:* Baseline from which swale geometry is projected.

*Radius:* Controls the radius of the rounded bottom. The radius can be zero for an angular swale.

*Grade:* Controls the grade (in %) at which the footprint is graded in cut.

*Behind the scene operations:*

- Creates a cut grid with rounded bottom.
- Combines it with finished grid using *Crown* operation.

**Tips:** The footprint must lie under the existing surface, otherwise the swale would not show up in the finished grid.

### ***Create Pond (AeccCreatePond)***

Adds a pond to the canvas using specified pond parameters.

#### Parameters:

*Feature line:* Controls the outside boundary of pond that is graded outside to existing ground.

*Rim elevation:* Controls the elevation of pond rim.

*Rim width:* Controls the width of pond rim. This value can be zero if the rim is not required.

*Depth:* Controls the pond depth.

*Wall grade:* The grade (in %) of pond wall.

*Outside Fill grade:* The grade (in %) at which the footprint is graded out in fill.

*Outside Cut grade:* The grade (in %) at which the footprint is graded out in cut.

*Behind the scene operations:*

- Creates a flat top plane at specified rim elevation.
- Offsets the outside boundary by specified rim width to create an inner boundary.
- Drapes the inner and outer rim boundaries on the plane.
- Creates a fill grid by grading outer boundary outward.
- Combines fill grid with finished grid using *Top Envelope* operation.
- Creates a cut grid by grading outer rim boundary outward.
- Combines cut grid with finished grid using *Bottom Envelope* operation.
- Creates a flat bottom plane bounded by inner rim boundary.
- Creates a fill grid by grading the inner boundary towards inside.
- Creates a pond interior from grids created in previous two steps using *Top Envelope* operation.
- Combines pond interior with finished grid using *Bottom Envelope* operation.

**Tip:** Use dimension grip to change the offset, and the pond would update dynamically.

### ***Create Spillway (AeccCreateSpillway)***

Creates a spillway along the rim of the pond within specified extents.

#### *Parameters:*

*Boundary:* A closed feature line that identifies the spillway boundary.

*Pond Boundary:* The boundary of the pond on which spillway is desired.

*Bottom Elevation:* The elevation of spillway base plane.

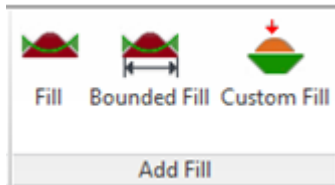
*Wall Grade:* The grade (in %) of spillway walls.

#### *Behind the scene operations:*

- Drapes the boundary on the pond rim.
- Creates a bounded horizontal plane boundary at specified elevation.
- Creates a bounded fill grid at specified wall grade.
- Combines plane and fill grid using *Top Envelope* operation.
- Combines the previous result with finished grid using *Bottom Envelope* operation.

**Tip:** Spillway base plane elevation should be higher than the required water-level in the pond.

### ***Tab: Add Fill***



### ***Add Fill (AeccAddFill)***

Grades the specified footprint in fill and adds the resulting geometry to the finished ground. This command provides options to grade at constant rate or transitioned rates.

#### *Parameters:*

*Feature Line:* Footprint to grade from.

*Side:* Controls the side to which the footprint is graded. If the footprint is not closed, then the side will be ignored and both sides will be graded.

*Infill Grid:* Controls the grid on which the closed footprint is draped. The geometry of the resulting grid on the non-graded side (side opposite to the graded side) of closed footprint is defined using the infill grid. If no infill grid is chosen, then no geometry will be created on that side.

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*Constant Grading:* Choose this option if constant rate of grading is desired.

*Grade:* Controls the flow grade (in %) at which the footprint is graded in fill if constant grading is selected.

*Transition Grading:* Choose this option to grade at slopes that transition from specified start to end grades.

*Start Grade:* Controls the flow grade (in %) at which the start point on footprint is graded in fill if transition grading option is selected.

*End Grade:* Controls the flow grade (in %) at which the end point on footprint is graded in fill if transition grading option is selected.

*Rounded Slope:* Choose this option if rounded top is desired.

*Radius:* Controls the radius of the rounded top.

### *Behind the scene operations:*

- Drapes the footprint on selected infill grid if selected.
- Creates a fill grid.
- Combines the fill grid with finished grid using *Top Envelope* operation.

**Tip:** If grading in transition, observe the contours in the transition zone near straight segments. The contours should be nearly straight.

### ***Add Bounded Fill (AeccAddBoundedFill)***

Grades the specified footprint in fill to the specified distance and adds the resulting geometry to the finished ground. This command provides options to grade at constant rate or transitioned rates and also produces an optional dynamic daylight curve.

### *Parameters:*

*Feature Line:* Footprint which is graded.

*Offset Distance:* Distance to which the footprint is graded.

*Infill Grid:* Controls the grid on which the closed footprint is draped. The geometry of the resulting grid on the non-graded side (side opposite to the graded side) of closed footprint is defined using the infill grid. If no infill grid is chosen, then no geometry will be created on that side.

*Constant Grading:* Choose this option if constant rate of grading is desired.

*Grade:* Controls the flow grade (in %) at which the footprint is graded in fill if constant grading is selected.

## Interactive Terrain Shaping

*Transition Grading:* Choose this option to grade at slopes that transition from specified start to end grades.

*Start Grade:* Controls the flow grade (in %) at which the start point on footprint is graded in fill if transition grading option is selected.

*End Grade:* Controls the flow grade (in %) at which the end point on footprint is graded in fill if transition grading option is selected.

*Rounded Slope:* Choose this option if rounded top is desired.

*Radius:* Controls the radius of the rounded top.

*Create Daylight:* Choose this option if daylight is desired.

### *Behind the scene operations:*

- Drapes the footprint on selected infill grid if selected.
- Creates a fill grid.
- Combines the fill grid with finished grid using *Top Envelope* operation.
- Creates an offset daylight and drapes it on the fill grid.

### **Tips:**

- If the offset distance is not large enough, the geometry will be combined with the finished ground with a near vertical wall. Use *AeccAddFill* (if daylight is completely above the finished ground) or *AeccRemCut* (if daylight is completely below the finished ground) with daylight line as the new footprint to tie the grid with finished ground smoothly.
- The value of system variable *OffsetGapType* must be set to 1 in order for this command to create correct shape.

### **Add Custom Fill (*AeccAddCustomFill*)**

Adds fill material represented by the selected grid to the finished ground.

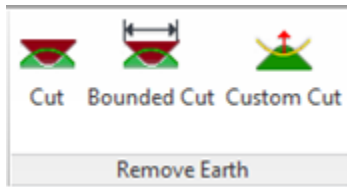
### *Parameters:*

*Fill Grid:* Grid representing fill geometry to be added to the finished ground.

### *Behind the scene operations:*

- Combines the selected grid with finished grid using *Top Envelope* operation.

## ***Tab: Remove Earth***



### ***Remove Cut (AeccRemCut)***

Grades the specified footprint in cut and removes the resulting geometry from the finished ground. This command provides options to grade at constant rate or transitioned rates.

#### *Parameters:*

*Feature Line:* Footprint to grade from.

*Side:* Controls the side to which the footprint is graded. If the footprint is not closed, then the side will be ignored and both sides will be graded.

*Infill Grid:* Controls the grid on which the closed footprint is draped. The geometry of the resulting grid on the non-graded side (side opposite to the graded side) of closed footprint is defined using the infill grid. If no infill grid is chosen, then no geometry will be created on that side.

*Constant Grading:* Choose this option if constant rate of grading is desired.

*Grade:* Controls the flow grade (in %) at which the footprint is graded in cut if constant grading is selected.

*Transition Grading:* Choose this option to grade at slopes that transition from specified start to end grades.

*Start Grade:* Controls the flow grade (in %) at which the start point on footprint is graded in cut if transition grading option is selected.

*End Grade:* Controls the flow grade (in %) at which the end point on footprint is graded in cut if transition grading option is selected.

*Rounded Slope:* Choose this option if rounded bottom is desired.

*Radius:* Controls the radius of the rounded bottom.

#### *Behind the scene operations:*

- Drapes the footprint on selected infill grid if selected.
- Creates a cut grid.
- Combines cut fill grid with finished grid using *Bottom Envelope* operation.

**Tip:** If grading in transition, observe the contours in the transition zone near straight segments. The contours should be nearly straight.

### ***Remove Bounded Cut (AeccRemBoundedCut)***

Grades the specified footprint in cut to the specified distance and removes the resulting geometry from the finished ground. This command provides options to grade at constant rate or transitioned rates and also produces an optional dynamic daylight curve.

#### *Parameters:*

*Feature Line:* Footprint which is graded.

*Offset Distance:* Distance to which the footprint is graded.

*Infill Grid:* Controls the grid on which the closed footprint is draped. The geometry of the resulting grid on the non-graded side (side opposite to the graded side) of closed footprint is defined using the infill grid. If no infill grid is chosen, then no geometry will be created on that side.

*Constant Grading:* Choose this option if constant rate of grading is desired.

*Grade:* Controls the grade (in %) at which the footprint is graded in cut if constant grading is selected.

*Transition Grading:* Choose this option to grade at slopes that transition from specified start to end grades.

*Start Grade:* Controls the grade (in %) at which the start point on footprint is graded in cut if transition grading option is selected.

*End Grade:* Controls the grade (in %) at which the end point on footprint is graded in cut if transition grading option is selected.

*Rounded Slope:* Choose this option if rounded bottom is desired.

*Radius:* Controls the radius of the rounded bottom.

*Create Daylight:* Choose this option if daylight is desired.

#### *Behind the scene operations:*

- Drapes the footprint on selected infill grid if selected.
- Creates a cut grid.
- Combines the cut grid with finished grid using *Bottom Envelope* operation.
- Creates an offset daylight and drapes it on the cut grid.

#### **Tips:**

- If the offset distance is not large enough, the geometry will be combined with the finished ground with a near vertical wall. Use *AeccAddFill* (if daylight is completely above the finished ground) or *AeccRemCut* (if daylight is completely below the finished ground) with daylight line as the new footprint to tie the grid with finished ground smoothly.
- The value of system variable *OffsetGapType* must be set to 1 in order for this command to create correct shape.

### ***Remove Custom Cut (AeccRemoveCustomCut)***

Removes earth represented by the selected grid from the finished ground.

#### *Parameters:*

*Cut Grid:* Grid representing cut geometry to be removed from the finished ground.

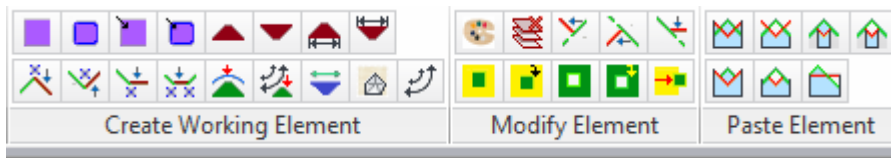
#### *Behind the scene operations:*

- Combines the selected grid with finished grid using *Bottom Envelope* operation.

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## Building Blocks

These commands are available on the last three ribbon tabs.



### ***Tab: Create Working Element***

#### ***Plane (AeccCreatePlane)***

Creates a *working* plane within the extents of the site boundary with specified parameters. The planar grid is not combined with the finished grid, but can be selected for *various* operations with any other grid, including the *finished* grid. (See appendix B for the definition of a *working* grid and a *finished* grid.)

#### *Plane parameters:*

*Key point:* Fixed 3D point in space through which the plane must pass.

*Grade sense (Downward/Upward):* The sense of plane slope specified through slope parameters.

*Flow direction:* The direction in plan along the path of steepest slope. This direction will be upward or downward based on specified grade sense.

*Grade:* The grade (in %) along the flow direction if the grade sense is downward and opposite to the flow direction if grade sense is upward.

**Tip:** To edit the plane parameters, sub-select the planar grid by pressing the CTRL key and clicking the grid. The grip for key point is displayed in both 2D and 3D view. The grade grip is displayed in the 3D view and the flow direction grip is displayed in the 2D view. Grip-edit and move them around to change the parameters, and the model will update dynamically.

### ***Bounded plane (AeccCreateBoundedPlane)***

Creates a working plane with specified parameters within the extents of the specified plane boundary.

#### *Parameters:*

*Key point:* Fixed 3D point in space through which the plane must pass.

*Grade sense (Downward/Upward):* The sense of plane slope specified through slope parameters.

*Flow direction:* The direction in plan along the path of steepest slope. This direction will be upward or downward based on specified grade sense.

*Grade:* The grade (in %) along the flow direction if the grade sense is downward and opposite to the flow direction if grade sense is upward.

*Plane Boundary:* The boundary (2D poly line or feature line) of the plane. If the boundary is not closed, then a new closed poly line will be created as a boundary.

**Tip:** The plane boundary must lie entirely inside the site boundary and can be of any shape. Modifying the boundary would update the extents of the grid dynamically.

### ***Flat Plane (AeccCreateFlatPlane)***

Creates a working flat plane within the extents of the site boundary.

#### *Parameters:*

*Key point:* Fixed 3D point in space through which the flat plane must pass.

### ***Bounded Flat Plane (AeccCreateFlatBoundedPlane)***

Creates a working flat plane within the extents of the specified plane boundary.

#### *Parameters:*

*Key point:* Fixed 3D point in space through which the plane must pass.

*Plane Boundary:* The boundary (2D poly line or feature line) of the plane. If the boundary is not closed, then a new closed poly line will be created as a boundary.

### ***Create Fill Grid (AeccCreateFillGrid)***

Creates a working grid whose geometry is created by projecting the selected footprint at specified fill (downward) slope(s).

#### *Parameters:*

*Feature Line:* Footprint to grade from.

*Side:* Controls the side to which the footprint is graded. If the footprint is not closed, then the side will be ignored and both sides will be graded.

*Infill Grid:* Controls the grid on which the closed footprint is draped. The geometry of the resulting grid on the non-graded side (side opposite to the graded side) of closed footprint is defined using the infill grid. If no infill grid is chosen, then no geometry will be created on that side.

*Constant Grading:* Choose this option if constant rate of grading is desired.

*Grade:* Controls the grade (in %) at which the footprint is graded in fill if constant grading is selected.

*Transition Grading:* Choose this option to grade at slopes that transition from specified start to end grades.

*Start Grade:* Controls the grade (in %) at which the start point on footprint is graded in fill if transition grading option is selected.

*End Grade:* Controls the grade (in %) at which the end point on footprint is graded in fill if transition grading option is selected.

*Rounded Slope:* Choose this option if rounded top is desired.

*Radius:* Controls the radius of the rounded top.

#### **Tips:**

- Do not choose finished grid as the draping grid if you want to combine the fill grid with finished grid using *Custom Fill* command. Otherwise, the fill grid will lie completely below the finished grid and would not show up at all after being combined with the finished ground.
- It is recommended that transitioned grades be only used on footprints that are not closed, as there will be an instantaneous change in grade at start/end points of closed footprints.

### ***Create Cut Grid (AeccCreateCutGrid)***

Creates a working grid whose geometry is created by projecting the selected footprint at a specified cut (downward) slope(s).

#### *Parameters:*

*Feature Line:* Footprint to grade from.

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*Side:* Controls the side to which the footprint is graded. If the footprint is not closed, then the side will be ignored and both sides will be graded.

*Infill Grid:* Controls the grid on which the closed footprint is draped. The geometry of the resulting grid on the non-graded side (side opposite to the graded side) of closed footprint is defined using the infill grid. If no infill grid is chosen, then no geometry will be created on that side.

*Constant Grading:* Choose this option if constant rate of grading is desired.

*Grade:* Controls the flow grade (in %) at which the footprint is graded in cut if constant grading is selected.

*Transition Grading:* Choose this option to grade at slopes that transition from specified start to end grades.

*Start Grade:* Controls the flow grade (in %) at which the start point on footprint is graded in cut if transition grading option is selected.

*End Grade:* Controls the flow grade (in %) at which the end point on footprint is graded in cut if transition grading option is selected.

*Rounded Slope:* Choose this option if rounded bottom is desired.

*Radius:* Controls the radius of the rounded bottom.

### Tips:

- Do not choose finished grid as the draping grid if you want to combine the cut grid with finished grid using *Custom Cut* command. Otherwise, the cut grid will completely lie above the finished grid and would not show up at all after being incorporated into the finished ground.
- It is recommended that transitioned grades be only used on footprints that are not closed, otherwise there will be an instantaneous change in grade at start/end points of closed footprints.

### ***Create Bounded Fill Grid (AeccCreateBoundedFillGrid)***

Creates a working grid (and an optional daylight curve) whose geometry is created by projecting the selected footprint at specified fill (downward) slope(s) to the specified distance.

#### *Parameters:*

*Feature Line:* Footprint which is graded.

*Offset Distance:* Distance to which the footprint is graded.

*Infill Grid:* Controls the grid on which the closed footprint is draped. The geometry of the resulting grid on the non-graded side (side opposite to the graded side) of closed footprint is defined using the infill grid. If no infill grid is chosen, then no geometry will be created on that side.

## Interactive Terrain Shaping

*Constant Grading:* Choose this option if constant rate of grading is desired.

*Grade:* Controls the flow grade (in %) at which the footprint is graded in fill if constant grading is selected.

*Transition Grading:* Choose this option to grade at slopes that transition from specified start to end grades.

*Start Grade:* Controls the flow grade (in %) at which the start point on footprint is graded in fill if transition grading option is selected.

*End Grade:* Controls the flow grade (in %) at which the end point on footprint is graded in fill if transition grading option is selected.

*Rounded Slope:* Choose this option if rounded top is desired.

*Radius:* Controls the radius of the rounded top.

*Create Daylight:* Choose this option if daylight is desired.

### **Tips:**

- Use *Custom Fill* operation to tie the bounded fill grid to the finished ground. If the value of offset distance is not large enough, this operation will use a near-vertical wall to tie the geometry to the finished ground.
- The value of system variable *OffsetGapType* must be set to 1 in order for this command to create correct shape.

### **Create Bounded Cut Grid (AeccCreateBoundedCutGrid)**

Creates a working grid (and an optional daylight curve) whose geometry is created by projecting the selected footprint at specified cut (upward) slope(s) to the specified distance.

#### *Parameters:*

*Feature Line:* Footprint which is graded.

*Offset Distance:* Distance to which the footprint is graded.

*Infill Grid:* Controls the grid on which the closed footprint is draped. The geometry of the resulting grid on the non-graded side (side opposite to the graded side) of closed footprint is defined using the infill grid. If no infill grid is chosen, then no geometry will be created on that side.

*Constant Grading:* Choose this option if constant rate of grading is desired.

*Grade:* Controls the grade (in %) at which the footprint is graded in cut if constant grading is selected.

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*Transition Grading:* Choose this option to grade at slopes that transition from specified start to end grades.

*Start Grade:* Controls the grade (in %) at which the start point on footprint is graded in cut if transition grading option is selected.

*End Grade:* Controls the grade (in %) at which the end point on footprint is graded in cut if transition grading option is selected.

*Rounded Slope:* Choose this option if rounded bottom is desired.

*Radius:* Controls the radius of the rounded bottom.

*Create Daylight:* Choose this option if daylight is desired.

### Tips:

- Use *Custom Cut* operation to tie the bounded cut grid to the finished ground. If the value of offset distance is not large enough, this operation will use a near-vertical wall to tie the geometry to the finished ground.
- The value of system variable *OffsetGapType* must be set to 1 in order for this command to work properly.

### ***Create Downward Pivot Plane (AeccCreatePivotPlaneDown)***

Creates a new bounded plane and combines it with the selected bounded grid to create a rapid grade transition that appears like a crown.

#### *Parameters:*

*Grid:* Controls the grid to which the new plane will be attached.

*Key point:* Controls the 2D point on the selected grid about which the new plane will be pivoted.

*Flow Direction:* The direction in plan along the path of steepest slope of the new plane.

*Flow grade:* The flow grade (in %) along the direction of steepest slope of the new plane.

*Plane Boundary:* The boundary (2D poly line or feature line) of the new plane.

#### *Behind the scene operations:*

- Creates a planar grid with specified parameters.
- Combines it with selected grid using *Bottom Envelope* operation.

### Tips:

- The elevation of the key point of the new plane would always be dynamically derived from the pivot point on the selected grid.

- The boundaries of the new plane and selected grid must intersect and the location of the pivot point must lie within the bounds of the selected grid as well as the new plane.

### ***Create Upward Pivot Plane (AeccCreatePivotPlaneUp)***

Creates a new bounded plane and combines it with the selected grid to create a rapid grade transition that appears like a sag.

#### *Parameters:*

*Grid:* Controls the grid to which the new plane will be attached.

*Key point:* Controls the 2D point on the selected grid about which the new plane will be pivoted.

*Upward Slope Direction:* The direction in plan along the path of steepest upward slope of the new plane.

*Upward grade:* The upward grade (in %) along the direction of steepest slope of the new plane.

*Plane Boundary:* The boundary (2D poly line or feature line) of the new plane.

#### *Behind the scene operations:*

- Creates a bounded planar grid with specified parameters.
- Combines it with selected grid using *Top Envelope* operation.

#### **Tips:**

- The elevation of the key point of the new plane would always be dynamically derived from the pivot point on the selected grid.
- The boundaries of the new plane and selected grid must intersect and the location of the pivot point must lie within the bounds of the selected grid as well as the new plane.

### ***Create Flat Pivot Plane (AeccCreatePivotPlaneFlat)***

Creates a new bounded flat plane and combines it with the selected grid to create a rapid grade transition from the given slope to flat grade.

#### *Parameters:*

*Grid:* Controls the grid to which the new plane will be attached.

*Key point:* Controls the 2D point on the selected grid about which the new plane will be pivoted.

*Crown/Sag:* Controls the appearance of the intersection edge between the new plane and the selected grid.

*Plane Boundary:* The boundary (2D poly line or feature line) of the new plane.

**Tip:** The location of the pivot point must lie within the bounds of the selected grid and the new plane.

### *Behind the scene operations:*

- Creates a flat planar grid.
- Combines it with selected grid using *Top Envelope* (for Sag) or *Bottom Envelope* (for Crown) operation.

### **Create Pivot Plane (*AeccCreatePivotPlane*)**

Creates a new bounded flat plane and combines it with two selected grids to create a rapid grade transition on given slopes.

#### *Parameters:*

*First Grid:* Specifies the first grid to which the new plane will be attached.

*Key point on First Grid:* Specifies the 2D point on the first grid about which the new plane will be pivoted.

*Crown/Sag for First Intersection:* Controls the appearance of the intersection edge between the new plane and the first grid.

*Second Grid:* Specifies the second grid to which the new plane will be attached.

*Key point on Second Grid:* Controls the 2D point on the second grid about which the new plane will be pivoted.

*Crown/Sag for Second Intersection:* Controls the appearance of the intersection edge of the new plane with the second grid.

*Plane Boundary:* The boundary (2D poly line or feature line) of the new plane.

**Tip:** The location of each pivot point must lie within the bounds of the selected grid and the new plane.

### *Behind the scene operations:*

- Creates a flat planar grid.
- Combines it with the first grid using *Top Envelope* (for Sag) or *Bottom Envelope* (for Crown) operation.
- Combines the previous result with the second grid using *Top Envelope* (for Sag) or *Bottom Envelope* (For Crown) operation.

### **Create Offset (*AeccCreateOffset*)**

Creates an offset feature line at specified offset distance.

#### *Parameters:*

*Feature Line:* The feature line whose offset is desired.

*Side:* Side at which the offset feature line is created.

*Distance:* The offset value.

**Tips:**

- Editing the offset dimension grip would update the offset feature line.
- The value of system variable *OffsetGapType* must be set to 1 before using this command.

### ***Drape Curve (AeccDrapeFeature)***

Drapes the selected feature line on the selected grid.

**Parameters:**

*Feature Line:* The feature line which needs to be draped.

*Grid:* Grid on which the feature line is draped.

**Tip:** Do not drape the boundary of a grid on the same grid. It will create a cyclical dependency. See the section on cyclical dependencies for details in appendix A.

### ***Create Draped Offset (AeccCreateDrapedOffset)***

Creates an offset feature line at specified offset distance and drapes it on the selected grid.

**Parameters:**

*Feature Line:* The feature line whose offset is desired.

*Side:* Side at which the offset feature line is created.

*Draping Grid:* Grid on which the offset feature line is draped.

- Editing the offset dimension grip would update the offset feature line.
- The value of system variable *OffsetGapType* must be set to 1 before using this command.

### ***Create Pond Storage (AeccCalcPondVolume)***

Brings a tool that shows the pond storage volume at a given water-level. The tool also shows the cut, fill and net volumes.

**Tip:** The storage volume would update when pond dimensions are modified. The storage volume would also update if the water surface is elevated or lowered by grip-editing in 3D. The tool can be used as an aid to design a pond for the required storage capacity while minimizing the earthwork simultaneously.

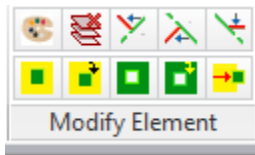
### ***Create Working Element from Tin (AeccCreateWorkingSurfGrid)***

Creates a working surface grid that mirrors the selected surface within the extents of the site boundary.

**Tip:** This command could be used as a helper command to paste surfaces that do not line up. Create a working surface grid from a surface to be pasted and combine it with the canvas (created from the existing surface) with *Add Fill* and/or *Remove Cut* operations by specifying a transition grade. This would blend the surfaces smoothly and get rid of the odd triangulation along the borders and gaps between the pasted surfaces. Observe the contours of the resulting canvas. They should be smooth.

---

### ***Tab: Modify Element***



### ***Edit Color (AeccEditElementColor)***

Changes the color of the selected grid.

**Tip:** Change the colors of various features (like swale in blue) to make them look real.

### ***Delete Working Element (AeccDeleteWorkingElement)***

Deletes the selected working grid. (See Appendix B for the definition of a working grid.)

**Tip:** Deleting a composite grid will not delete the grids that got combined to form the composite grid. Unless deleted explicitly, these grids will become new working grids.

### ***Grade Break: Sag (AeccCreateGradeBreakMax)***

Creates a new plane and combines it with the selected grid to create a rapid grade transition that appears like a sag.

#### *Parameters:*

*Grid:* Controls the grid to which the new plane will be attached.

*Key point:* Controls the 2D point on the selected grid about which the new plane will be pivoted.

*Upward Slope Direction:* The direction in plan along the path of steepest upward slope of the new plane.

*Upward grade:* The grade (in %) along the steepest upward direction of the new plane.

**Tip:** The elevation of the key point of the new plane would always be derived from the pivot point on the selected grid. If the pivot grid is modified, the elevation of the new plane at the pivot point will be

updated dynamically. The pivot point can be edited in plan by moving the key point grip of the new plane.

### *Behind the scene operations:*

- Creates a planar grid with specified plane parameters.
- Combines it with selected grid using *Pull Up* operation.

### ***Grade Break: Crown (AeccCreateGradeBreakMin)***

Creates a new plane and combines it with the selected grid to create a rapid grade transition that appears like a crown.

#### *Parameters:*

*Grid:* Controls the grid to which the new plane will be attached.

*Key point:* Controls the 2D point on the selected grid about which the new plane will be pivoted.

*Flow direction:* The direction in plan along the path of steepest slope.

*Flow grade:* The grade (in %) along the flow direction.

**Tip:** The elevation of the key point of the new plane would always be derived from the pivot point on the selected grid. If the pivot grid is modified, the elevation of the new plane at the pivot point will be updated dynamically. The pivot point can be edited in plan by moving the key point grip of the new plane.

### *Behind the scene operations:*

- Creates a planar grid with specified plane parameters.
- Combines it with selected grid using *Push Down* operation.

### ***Grade Break: Flat (AeccCreateGradeBreakFlat)***

Creates a new flat plane and combines it with the selected grid to create a rapid transition of given slope to flat plane.

#### *Parameters:*

*Grid:* Controls the grid to which the new plane will be attached.

*Key point:* Controls the 2D point on the selected grid about which the new plane will be pivoted.

*Crown/Sag:* Controls the appearance of the intersection edge between the new plane and the selected grid.

*Behind the scene operations:*

- Creates a flat planar grid with specified plane parameters.
- Combines it with selected grid using *Push Up* (for Sag) or *Pull Down* (for Crown) operation.

***Create Bounds (AeccCreateBounds)***

Bounds a grid on all sides with specified closed boundary.

*Parameters:*

*Grid:* Grid to be bounded.

*Boundary:* Closed feature line or 2D poly line that will be used as the grid boundary.

**Tip:** Use this command to trim the unwanted regions in unbounded grading.

***Create Hole (AeccCreateHole)***

Creates a hole in the selected grid with specified boundary.

*Parameters:*

*Grid:* Grid in which hole is to be created.

*Boundary:* Closed feature line or 2D poly line that will be used as a boundary of the hole.

**Tip:** Use this command to get rid of unwanted regions in unbounded grading.

***Drape and Create Bounds (AeccDrapeAndBound)***

Drapes a closed boundary on the grid and converts it to a bounded grid.

*Parameters:*

*Grid:* Grid to be bounded.

*Boundary:* Closed feature line to be draped and used as the grid boundary.

**Tip:** Use this command to trim the working geometry with boundary as a cutting edge and later tie it with the finished ground using the draped boundary. This step is an alternative way of creating a draped boundary that does not create cyclical dependencies.

***Drape and Create Hole (AeccDrapeAndCreateHole)***

Drapes a closed boundary on the selected grid and creates a hole in it.

*Parameters:*

*Grid:* Grid in which hole is to be created.

*Boundary:* Closed Feature line to be draped and used as a boundary of the hole.

### ***Extend Bounds (AeccExtendBounds)***

Extend bounds of the selected bounded grid by the given boundary.

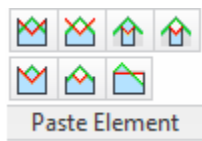
#### *Parameters:*

*Grid:* Bounded grid whose bounds need to be extended.

*Boundary:* Closed Feature line or 2D polyline used for extending the boundary.

---

### ***Tab: Paste Element***



### ***Top Envelope (AeccCreateMaxOpGrid)***

Creates a grid that represents the top bounding envelope of selected grids. The elevation of any point in the resulting grid represents the highest elevation in the selected grids at that point.

**Tip:** Pair *AeccCreateFillGrid* and *AeccCreateMaxOpGrid* in that sequence to add fill to the existing ground.

### ***Bottom Envelope (AeccCreateMinOpGrid)***

Creates a grid that represents the bottom bounding envelope of selected grids. The elevation of any point in the resulting grid represents the lowest elevation in the selected grids at that point.

**Tip:** Pair *AeccCreateCutGrid* and *AeccCreateMinOpGrid* in that sequence to remove cut from the existing ground.

### ***Top Overlap Envelope (AeccCreateOverlapMaxOpGrid)***

Creates a grid that represents the top bounding envelope of overlapping region of selected grids. The elevation of any point in the resulting grid represents the highest elevation in the selected grids at that point. A point that is not present in both selected grids is not included in the final result.

### ***Bottom Overlap Envelope (AeccCreateOverlapMinOpGrid)***

Creates a grid that represents the bottom bounding envelope of overlapping region of selected grids. The elevation of any point in the resulting grid represents the lowest elevation in the selected grids at that point. A point that is not present in both selected grids is not included in the final result.

### ***Pull Up (AeccCreateMaxKeepBaseOpGrid)***

Elevates a portion of the base grid using the geometry of the second grid. The elevation at any point in the resulting grid represents the highest elevation in the selected grids. The horizontal extents of the resulting grid are determined by the base grid.

### ***Push Down (AeccCreateMinKeepBaseOpGrid)***

Depresses a portion of the base grid using the geometry of the second grid. The elevation at any point in the resulting grid represents the lowest elevation in the selected grids. The horizontal extents of the resulting grid are determined by the base grid.

### ***Fasten with a Wall (AeccReplaceOverlap)***

Attaches an overlapping grid with the base grid using a wall.

#### *Parameters:*

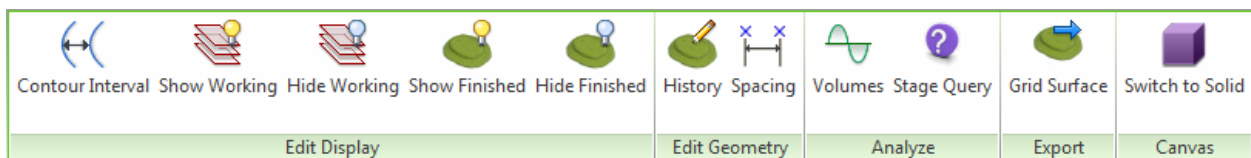
*Base Grid:* The main grid whose geometry is modified with the overlapping grid.

*Overlapping Grid:* The smaller overlapping grid to be attached to the base grid.

**Tip:** Use this command to integrate the working geometry into the finished ground by choosing finished ground as base grid and working grid as overlapping grid. For example, create a working bounded plane above the finished ground and attach it with this command to create a traffic island.

## **Contextual Commands (Grid)**

These commands are available in the contextual tab when the grading grid is displayed in grid mode.



### ***Contour Interval (AeccSetContourInterval)***

Changes the interval at which contours in grading grid are drawn in 2D view.

**Tip:** To see grid points as point markers in addition to contours in 2D view, set the grid spacing to a value of 5 or more.

### ***Show Working Geometry (AeccShowWorkingGrids)***

Turns on the visibility of the working geometry if hidden.

### ***Hide Working Geometry (AeccHideWorkingGrids)***

Turns off the visibility of the working geometry. This allows the user to focus on finished ground and its operations.

### ***Show Finished Ground (AeccShowFinishedGrid)***

Turns on the visibility of the finished ground if hidden.

---

### ***Hide Finished Ground (AeccHideFinishedGrid)***

Turns off the visibility of the finished ground. This allows the user to focus on the working geometry and its operations.

### ***Edit History (AeccEditHistory)***

Brings a user interface to show operations added to the finished ground with ability to delete or reorder them.

**Tip:** Use this command to reorder features that overlap each other to give a different result.

### ***Edit Grid spacing (AeccSetGridSpacing)***

Changes the spacing of grid points in the selected grading grid. The default spacing is 3 units. Reducing the spacing would improve the quality of the model, at the expense of time to update.

**Tip:** Grid density can be refined to seamlessly transition a preliminary design to a finished plan, from which the production drawings and contours can be produced, while retaining the early design information.

### ***Total volume (AeccCalcTotalVolume)***

Brings a tool that shows cut, fill and net volumes for the current stage.

**Tip:** The volumes would update when canvas is modified. The tool can be used as an aid to minimize the earthwork by manually editing pieces of canvas.

### ***Stage Query (AeccStageVolume)***

Computes cut/fill/net volumes at the selected stage in finished surface. This command can be used to do the volume differences between the intermediate stages.

**Tip:** Sub-select the existing grid and continue sub-selecting (in 3D view) to scroll through the intermediate stages and run the volume command to see volumes at that stage.

### ***Export Finished (AeccExportFinished)***

Creates a light-weight Civil Grid Surface from the grading grid if viewed in the grid mode.

**Tip:** This operation is slow. Reduce the grid density to speed up the creation of the grid surface.

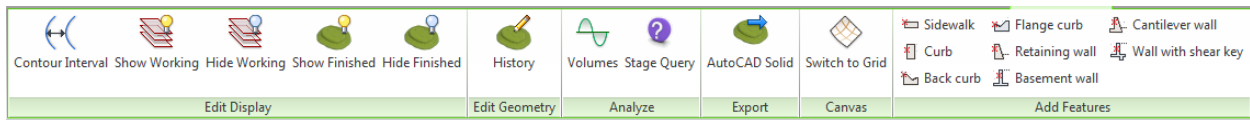
### ***AeccSwitchToSolid (AeccSwitchToSolid)***

Converts the grading grid to the solid model.

**Tip:** This operation is slow but allows to view the model with accurate hard edges and true vertical walls.

## **Contextual Commands (Solid)**

These commands are available in the contextual tab when the grading grid is displayed in solid mode.



### ***Export Finished (AeccExportFinished)***

Creates an AutoCAD 3D Solid from the grading grid, when viewed in the solid mode.

### ***Switch ToGrid (AeccSwitchToGrid)***

Converts the grading grid to the grid model.

### ***Create Sidewalk (AeccCreateSidewalk)***

Creates a sidewalk along the selected feature line on the given side.

### ***Create Curb (AeccCreateCurb)***

Creates a curb along the selected feature line on the given side.

### ***Create Back Curb (AeccCreateBackCurb)***

Creates a back curb along the selected feature line on the given side.

### ***Create Flange Curb (AeccCreateFlangeCurb)***

Creates a flange curb along the selected feature line on the given side.

### ***Create Retaining Wall (AeccCreateRetainingWall)***

Creates a retaining along the selected feature line on the given side.

### ***Create Basement Wall (AeccCreateBasementWall)***

Creates a basement wall along the selected feature line on the given side.

### ***Create Cantilever Wall (AeccCreateCantileverWall)***

Creates a cantilever wall along the selected feature line on the given side.

### ***Create Wall with Shear Key (AeccCreateShearKeyWall)***

Creates a wall with shear key along the selected feature line on the given side.

## Appendix A: Limitations of the current model

### Size

The current model cannot handle very large areas. We recommend that the number of grid-points be kept under 100,000 for good performance. For example, let's say that the extents of the working space are 300' X 900'. When the grading grid is first created, the default spacing is 3 feet. Thus, the model will generate 30,000 points, which will work well as it is below the specified upper limit of 100,000 points. To work with larger areas, reduce the grid density and then stretch the site boundary.

### Filers

The drawings can be saved and reopened in the current preview version. However, the future versions of the product will not support drawings that get saved in the current version. All grading grid objects saved in the current version will be converted into proxies in future versions. Moreover, if you open these drawings without loading the required modules, the grading grid objects will again be converted into proxies.

### Solids

Solid model is a bit slow for some grading shapes and may not succeed for all operations but we have included this ability in the preview because we want to show future direction. It is recommended that all model edits be done in grid mode.

### Cyclical dependencies

It is possible to create cyclical dependencies if the commands are not used correctly. Cyclical dependencies are created when circular references are created among grids dependent upon each other. The solver would fail in the presence of such cyclical dependencies. For example, draping a feature line on a grid that is derived (directly or indirectly) from the same feature line could create a case for cyclical dependency. Precautions must be taken to avoid this.

### No-site feature lines

The feature lines representing footprints, boundaries and offsets may end up in the same site. As a result, they may get entangled with each other due to elevation priority. We recommend moving each feature line to its own site, by using *MoveToSite* command. In addition, we recommend using 2d poly lines as plane boundaries, if these boundaries will not be used later to create gradings.

Other known defects are as follows:

- The offset dimension grip is not fully functional. Editing the offset leads to the desired result, however the dimension grip is not reactive to changes in footprint geometry. So, it may need to be positioned manually after updates.
- When the grading grid is sub-selected inside of a command, it may not get un-selected when ESC is pressed. To un-select, click on any drawing object, and then hit ESC.
- In very rare circumstances, the grading grid may not update completely. To trigger a complete update, move the site boundary by zero displacement.

## Interactive Terrain Shaping

- The volumes shown in the volume tool do not update on undo. To see the correct volumes following an undo, just move the site boundary by zero displacement.

## Appendix B: Definitions

### *Working Grid*

A grid that has not been combined with the finished grid is called a working grid. The working grid can be combined with another working grid to create a new composite working grid. A working grid (atomic or composite) can also be combined with the finished grid. Once the working grid has been combined with any other grid, it is not displayed independently in the final result.

### *Op Grid*

A grid that is produced by combination of other grids through various paste operations is called an op grid.

### *Atomic Grid*

A grid that is completely independent of other grids is called an atomic grid. Planar grids and surface grids are examples of atomic grids. A pure cut/fill grid is also an atomic grid. Atomic grids are examples of working grids.

### *Composite Grid*

A grid that is created by combining two or more grids is a composite grid. For example, a cut/fill grid that contains an infill grid is a composite grid. Op grids are always composite.

### *Finished Grid*

The final grid that is the result of combining the existing surface with working grids is a finished grid. It represents the finished ground. All commands categorized as custom commands apply operations to finished grid and modify it to present the finished ground.

### *Working Geometry*

All working grids collectively are referred to as working geometry.

**Tip:** Grids are sub-entities of grading grid, identified by contour color in 2D view and face color in 3D view. To select a grid, press CTRL and click on a grid. The selected grid will show up in extended view. To select a composite grid, continue CTRL+clicking (in 3D view) till the desired grid is selected. Then press Enter.