



Chapter 3

Site Analysis

With the exception of the International Space Station, no building exists without a site. Experienced architectural practitioners intimately understand that building design is lacking an important dimension without careful consideration of the site ([Fig. 3.1](#)). Buildings are not objectified artifacts that are isolated from experience (that is, inhabitation) or divorced from context (or site). Further, proper sustainable site design requires a quantitative understanding of site conditions: topography, solar orientation, prevailing winds, and so on. This is nothing new, of course, but BIM presents an opportunity to integrate manipulable site data into the design process in an immediate and recursive way ([Fig. 3.2](#)). This chapter frames the discussion of the role of BIM in the analysis and design of sustainable sites.

FIGURE 3.1 Addressing steep or difficult topography is one obvious way in which a robust site model is an important

FIGURE 3.1 Addressing steep or difficult topography is one obvious way in which a robust site model is an important dimension of BIM.

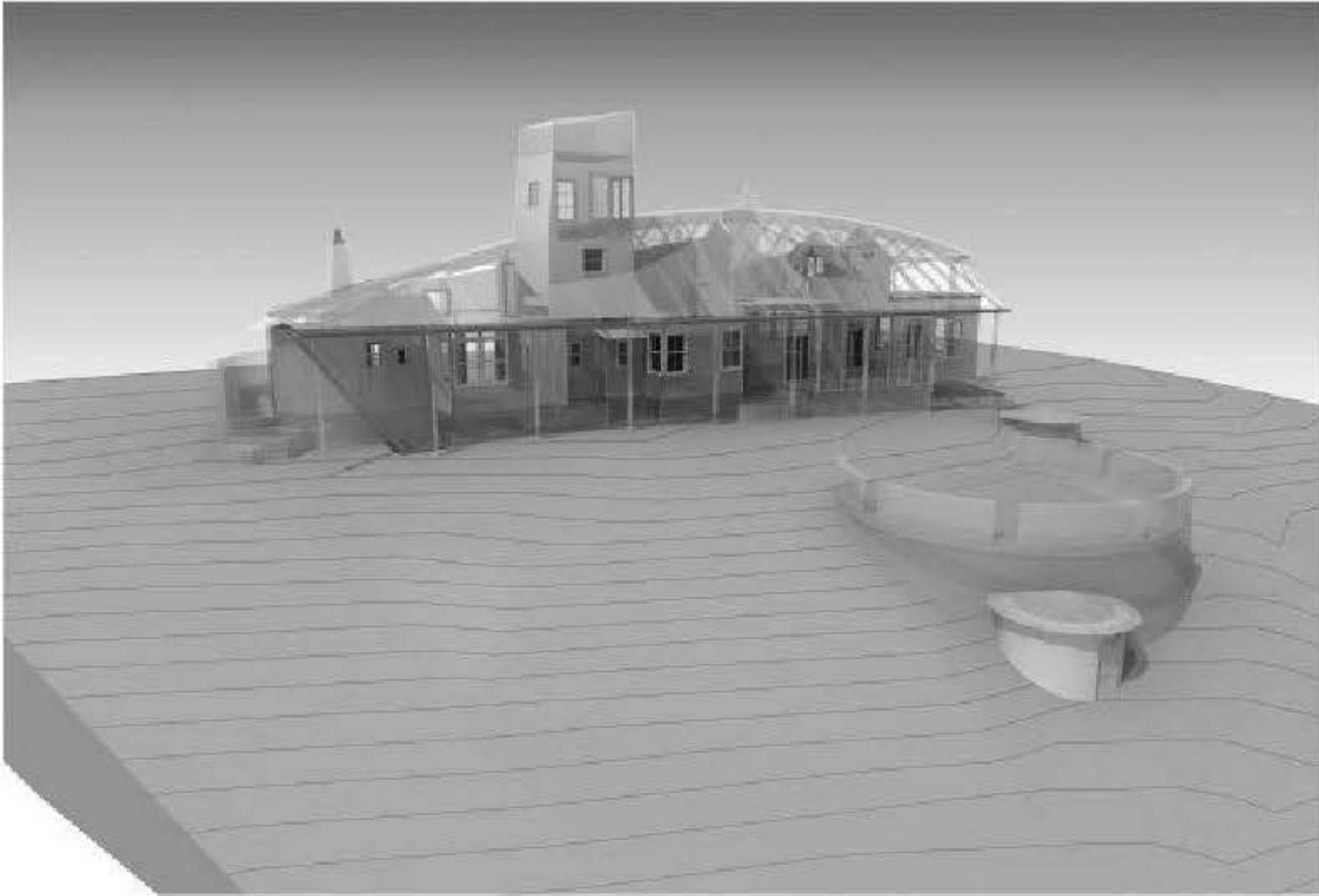
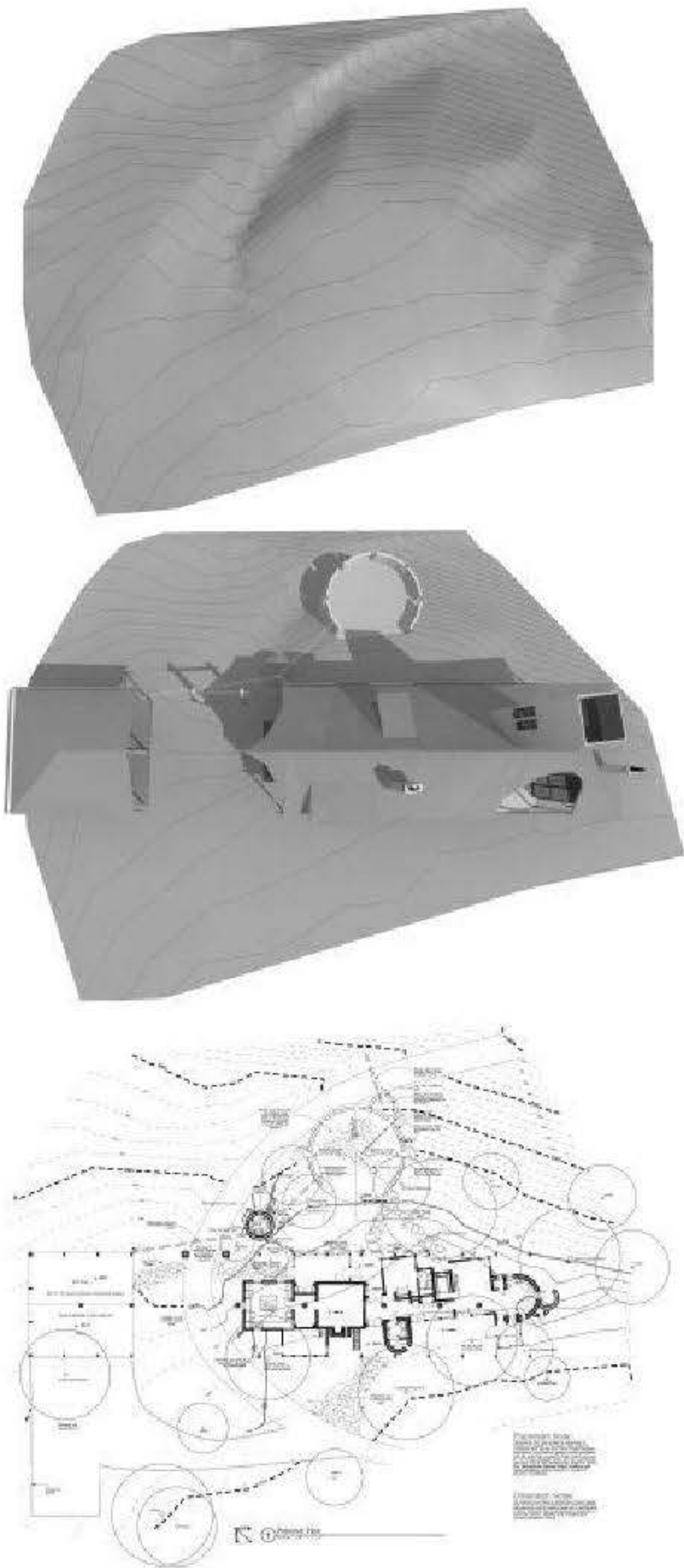


FIGURE 3.2 Three plan views of site models: a rendered mesh, a 3D view including the building, and drawing from the construction documents. All three views are of the same site model.



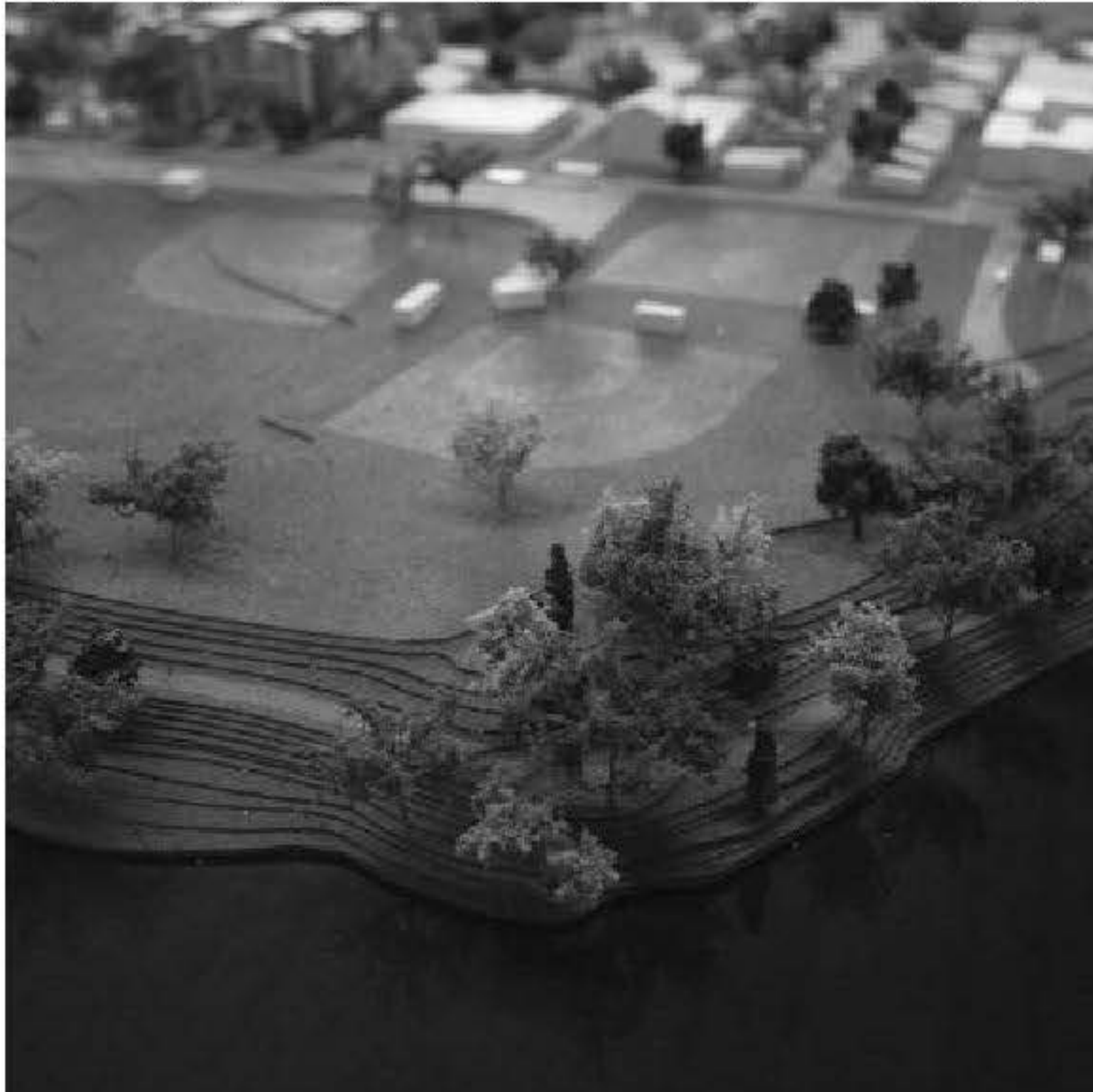
Developing a site model

Traditionally, architects have documented, analyzed, designed, and communicated site information in one of two ways: through drawings or physical models. Of the two, the former has traditionally been a more flexible and powerful tool in large part due to its graphic abstractness and the convention of topography lines. Site plans and their topographies can readily be manipulated with a pencil and quantified with a scale. With these simple tools and a little arithmetic, grades,

slopes, and elevations can be drawn, studied, analyzed, changed, and finalized. Physical site models have until recently been extremely time-consuming to make, particularly for large and complex sites. The advent of digital fabrication technologies (laser cutters, computer controlled routers, and to a growing extent 3D printers) has facilitated physical site model production, but the process is still time consuming, and at the time of this writing few firms, particularly small ones, have digital fabrication capabilities in-house. Most physical site models are thus still cut and glued by hand. As useful as they are for visualization and presentation, for most projects, only a handful of iterations of the site at most are constructed ([Fig. 3.3](#)).

FIGURE 3.3 Digital fabrication does not exclude hand modeling. Here the contours were digitally fabricated directly from CAD contours, and formed the base for a hand-made site model.

Image courtesy of Flying Fish Designs and Studio Maquette. Photograph by Veronica Winford.



But as with all drawings, coordination can be problematic. Agreement between site plan, ground floor plan, building elevations, and building sections can be tedious, time consuming, at times complex, and prone to error. This is particularly the case as the designer regrades the site to accommodate the building, and adjusts the building to better fit the site; a well-sited building may require several design iterations to best fit its location. With views extracted from a building model that includes digital terrain, however, coordination of building and site can be automated ([Fig. 3.4](#)). Most site models consist of meshes of triangular 3D polygons, or triangulated irregular networks (TINs) ([Fig. 3.5](#)). There are several possible approaches to the preparation of a digital terrain model (DTM), depending on the needs of the designer, software tools employed, and the nature of available site or survey data.

FIGURE 3.4 As in reality, in BIM the building model may interact with the site. Here, the site model has been regraded to meet the building, coordinating the ground floor plan and site conditions.

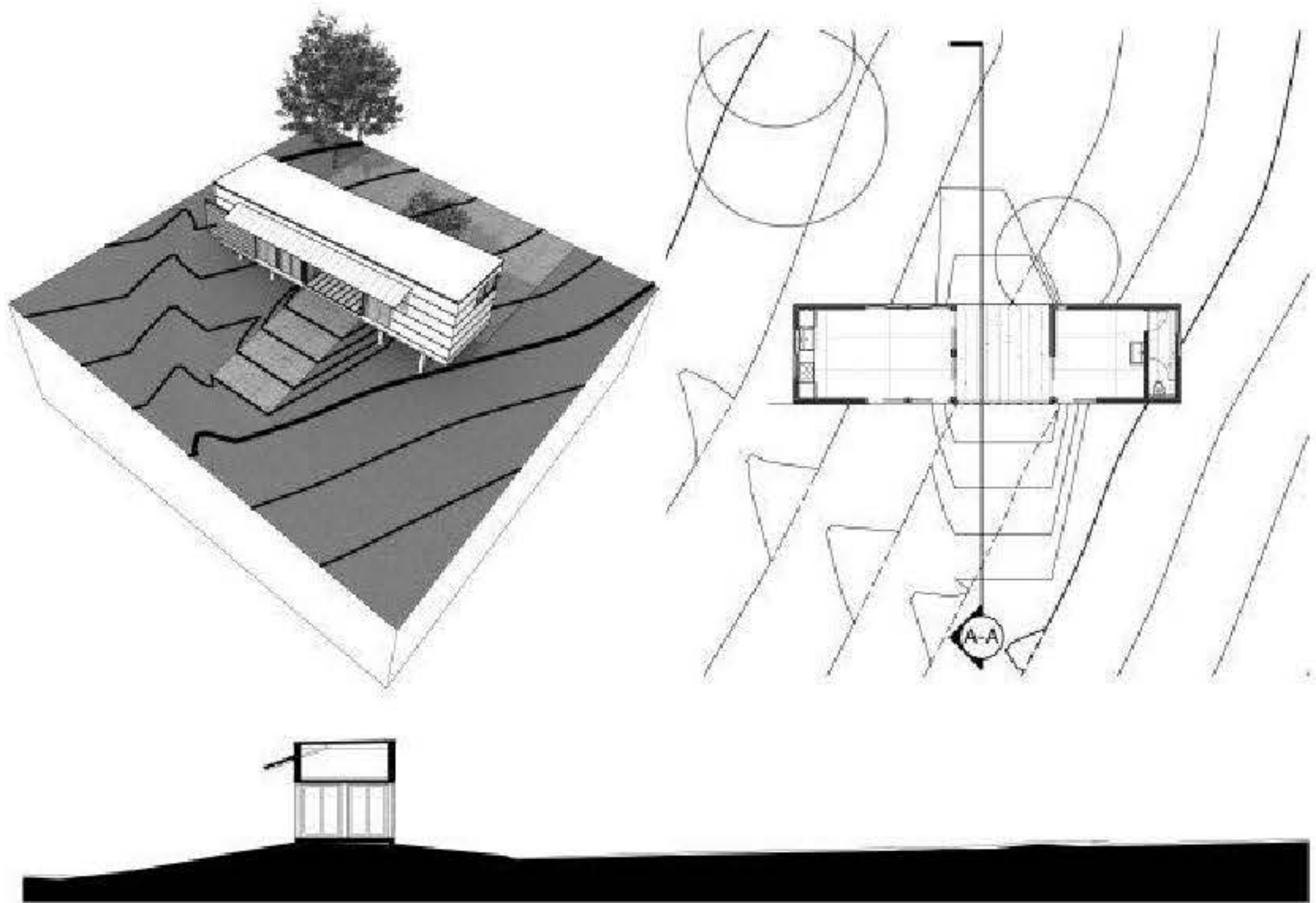
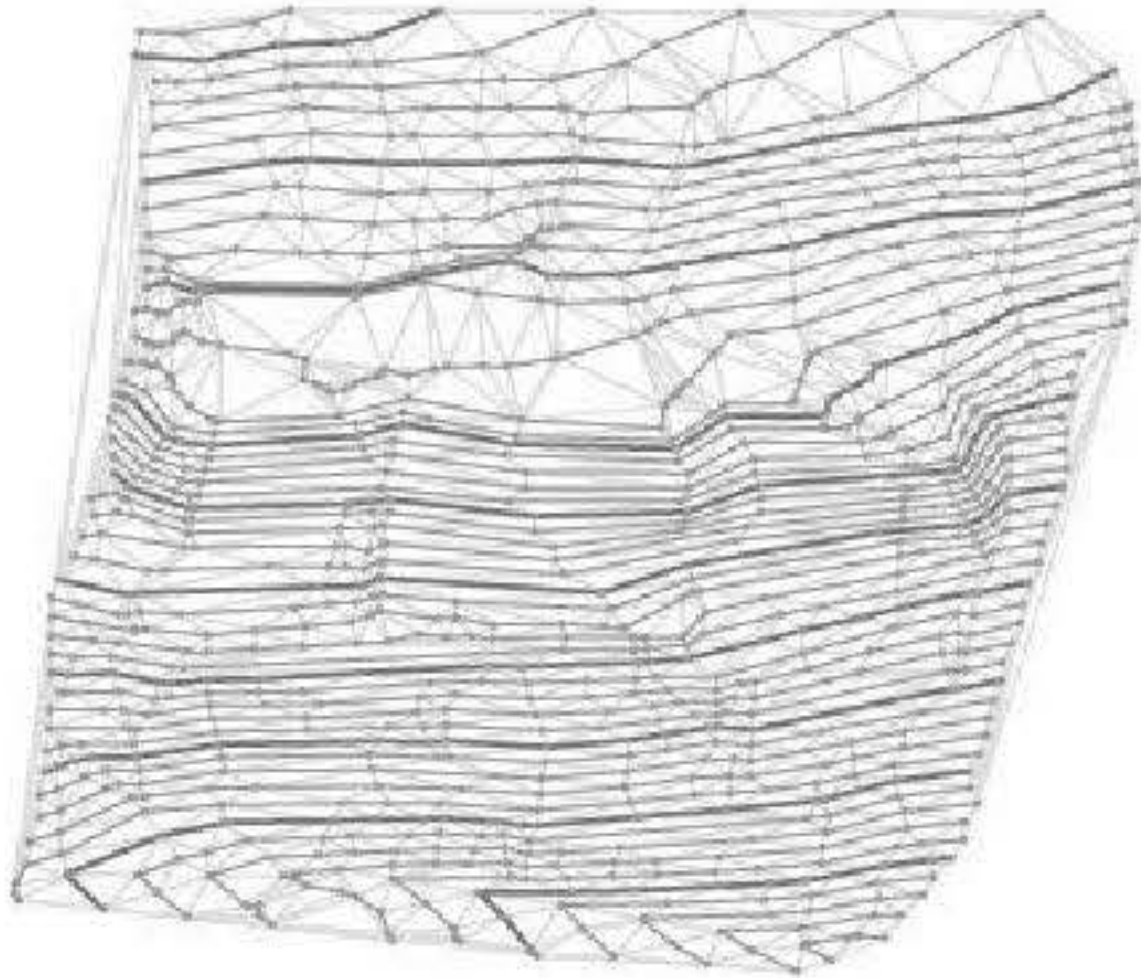


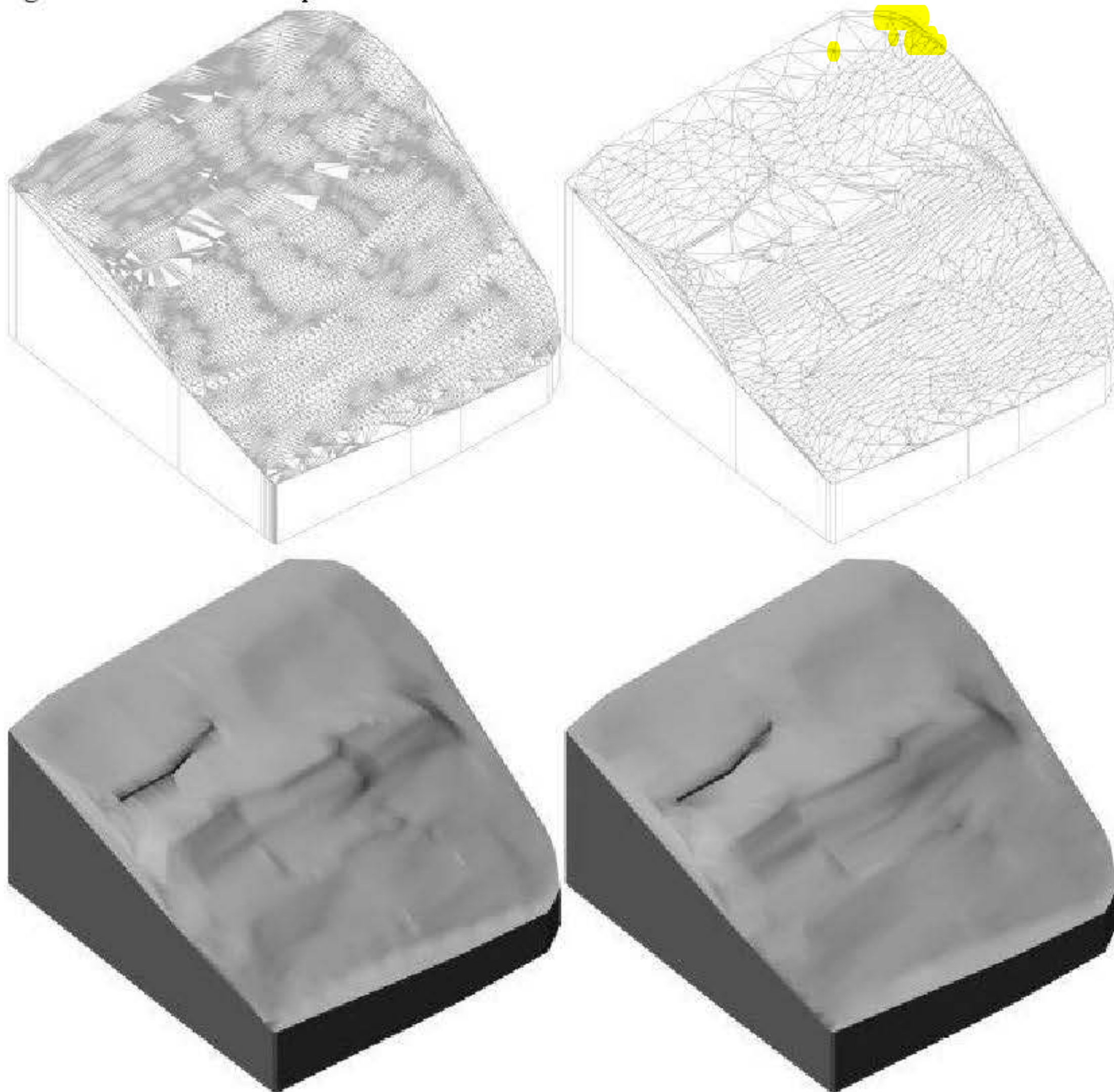
FIGURE 3.5 A triangulated irregular network (TIN) site model. The x , y , z coordinate vertices that constitute the actual data points generating the TIN have been highlighted with dots.



Generally, inexperienced users tend to err on the side of providing too much detail in a model rather than not enough. (A model is, after all, just that: an abstraction, as opposed to a miniature, which seeks to faithfully represent every aspect of the original.) This is true for site models as well, where the novice is often apt to create or reproduce as “faithful” or nuanced a contour as possible. This tendency may lead to terrain models whose resolution is far too high. For example, given a sinuous Bézier contour in [Figure 3.6](#), one might be tempted to reproduce it as a polygonal approximation of several thousand points (top left). However, as can be seen, even a rough approximation may lead to an acceptable terrain model, provided it preserves the inflections of the original (right).

FIGURE 3.6 The site model at left is derived from smooth cubic spline polylines that, when converted to 3D polygons, yields almost 8,000 vertices. The one at left is composed of more angular polygonal approximations with less than a

thousand vertices. The rendered views below are of the same respective site models; thanks to smoothing algorithms, the coarser site model (with much faster computation and rendering times) appears just as smooth or smoother than its high-vertices-count counterpart.



There are four views that one might expect from a site model:

- A traditional site plan view, with equal-interval contours;
- An analytical plan view, for example color-coded to slope or indicating flow arrows;
- A rendered 3D view, such as a perspective;
- A site section (and, by extension, a building elevation that shows existing and/or finished grade relative to the building).

In the case of the first, it happens that TIN models may be acceptable at a lower resolution (that is, possessing fewer data points, or 3D vertices) than one might expect, for several reasons. Many applications, from BIM modelers like Revit and Vectorworks, to surface modelers like SketchUp, are able to use rendering algorithms to make faceted site models appear smooth in 3D rendered views. This has the significant benefit of drastically reducing rendering times, as a smoothed, faceted model may be calculated and rendered much faster than one that owes its smoothness to having

significantly more data points (what has been termed here “higher resolution”). Hence smooth, high-vertex-count contours may safely be reduced in resolution with little loss in quality. The designer should take care to maintain each contour’s general shape (inflection). If the number of vertices is reduced by means of an automated script or command, inspect the simplified contours to insure that highly inflected, close-set contours do not end up crossing nearby contours. Most TINs do not allow perfectly shear faces (contours stacked on top of one another), nor “caves” (crossed contours).

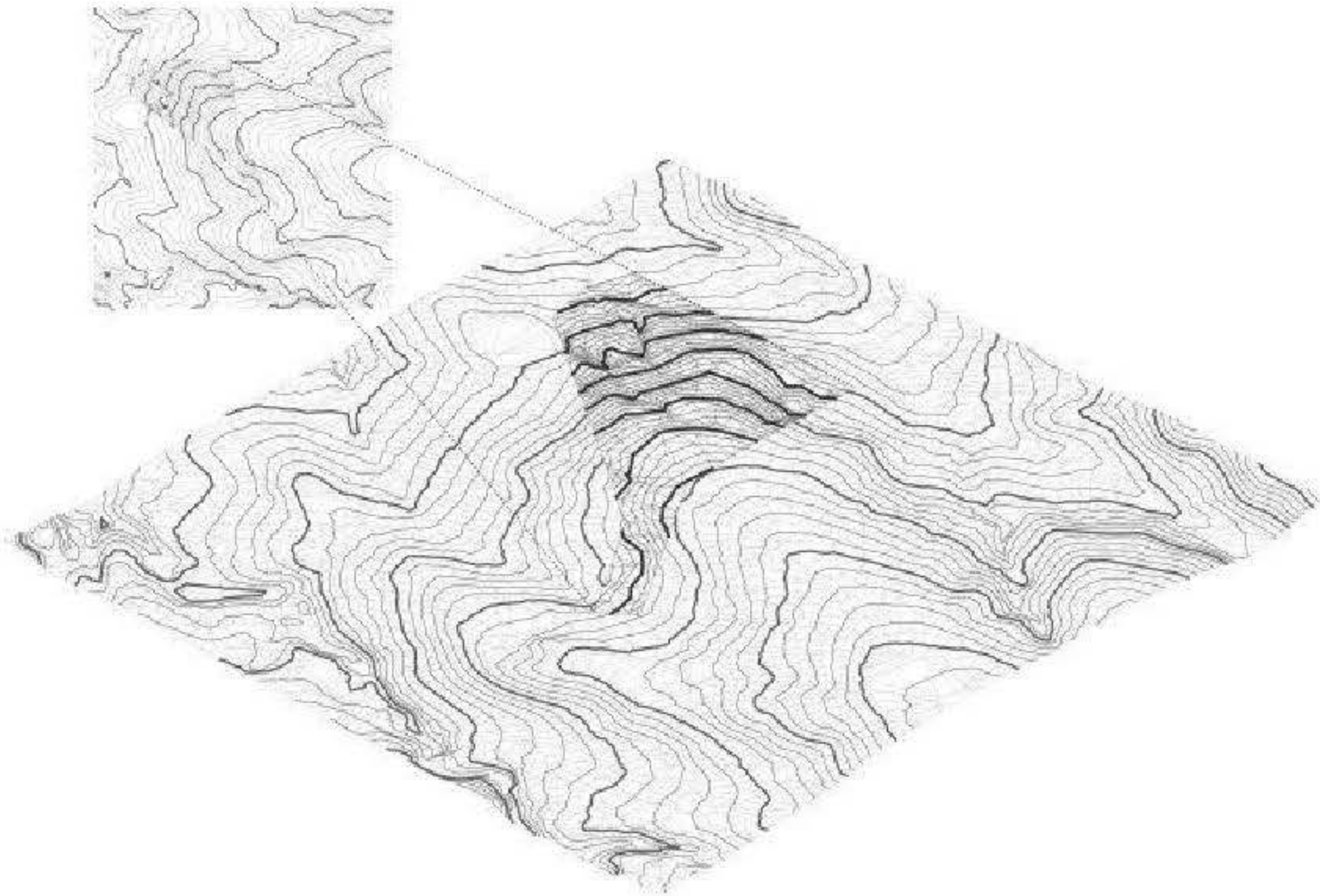
It may also bear mentioning that most survey contours are themselves interpolations and approximations based on a few data points. Reducing a contour to a more faceted polygon does not necessarily represent a loss of true data ([Fig. 3.6](#), top and lower right).

As most site sections have little dramatic inflection in the finished or existing grade line, a lower resolution TIN once again may produce very satisfactory results. Site sections and building elevations may realize little benefit from high-resolution TINs, yet the user may pay for the high number of data points with a high computational penalty: slow calculations, regenerations, and renderings.

It may be difficult to make a blanket assessment of what constitutes too high a resolution for a TIN and what is an appropriate low (but not too low) resolution of data. Variables such as the size and scale of the project, the relative uniformity of site grade, the capabilities of the software, and the computational power available to the designer are all significant factors. Unfortunately, some trial and error may be necessary for a particular designer to determine an ideal minimum and maximum number of 3D vertices for a “typical” model. As a point of departure, I have produced very convincing site models of far less than 50,000 3D vertices; 100,000 3D vertices is probably an upper limit at the time of this writing for most software and hardware to handle without excessive sluggishness.

If the designer needs an extended site model that may have only one or a few areas of particular interest, one useful technique is to “nest” site models ([Fig. 3.7](#)). Using this method, a large area (over which little or no construction is to take place, but which is to serve as site context) is modeled at a relatively low resolution (and smoothly rendered). Smaller areas of interest are modeled at a much higher resolution, and inset into the larger site context model. In this way, one benefits from having a large model expanse, which is more highly detailed only in needed portions in order to reduce computational cost, or rendering times.

FIGURE 3.7 To reduce computational cost, it may be acceptable to have an extended site model generated at a coarser data resolution, within which a more precise site model is nested. Here a higher polygon count site model for a site of interest is inserted in a larger (and less precise) site model. The larger model is derived from aerial geographic information system (GIS) data; the inset site was surveyed on the ground by a licensed surveyor.

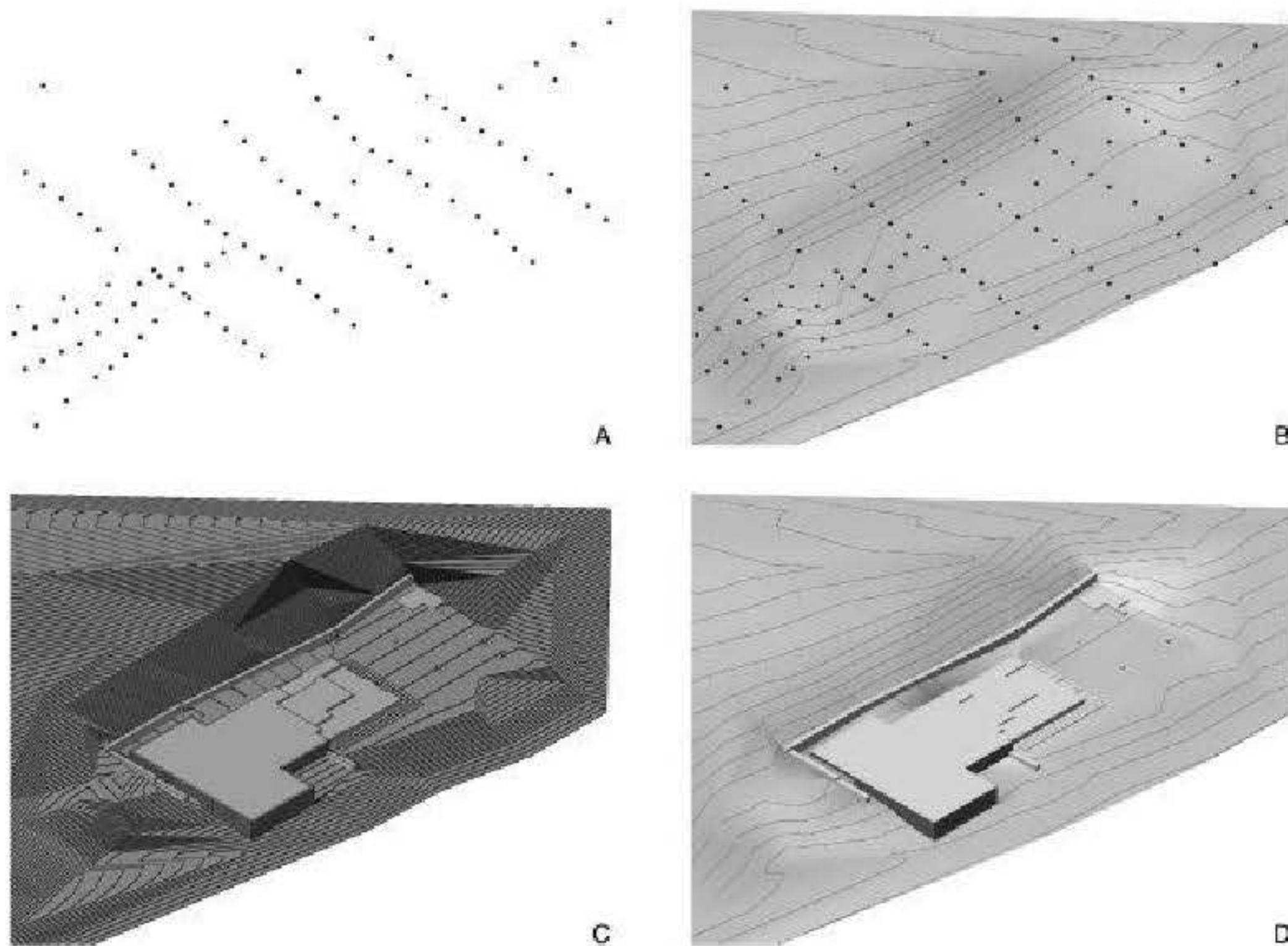


From rough field surveys

The designer may wish to perform an informal field survey in order to establish preliminary site conditions: a survey may not yet be available, or the project may be at a feasibility stage and not warrant a survey. With basic surveying techniques a few data points may be established ([Fig. 3.8](#)). This is particularly useful where the designer may possess a 2D site plan with no topographical information (such as a metes and bounds or plot plat) and can add elevation information. An arbitrary benchmark may be established and approximate or exact elevations can be taken relative to that benchmark: at tree locations, existing building corners, and so on. A simple surveyor's hand level may be used, or even a measuring tape can indicate existing finish floor above grade at building edges.

FIGURE 3.8 The development of a site model: the architect made field topography measurements (vertices, upper left, and superimposed over generated site TIN, upper right) and constructed the site model in Vectorworks. The bottom left view shows the preliminary site model reggraded with the building slab modeled; at bottom right is the smoothed site. The previous owner had excavated a portion of an existing slope and the new owners wanted to use this area for placement of their home. The model and siting were so accurate that the foundation contractor confirmed the recommended removal of an additional 9 inches at the northwest corner of the existing excavation.

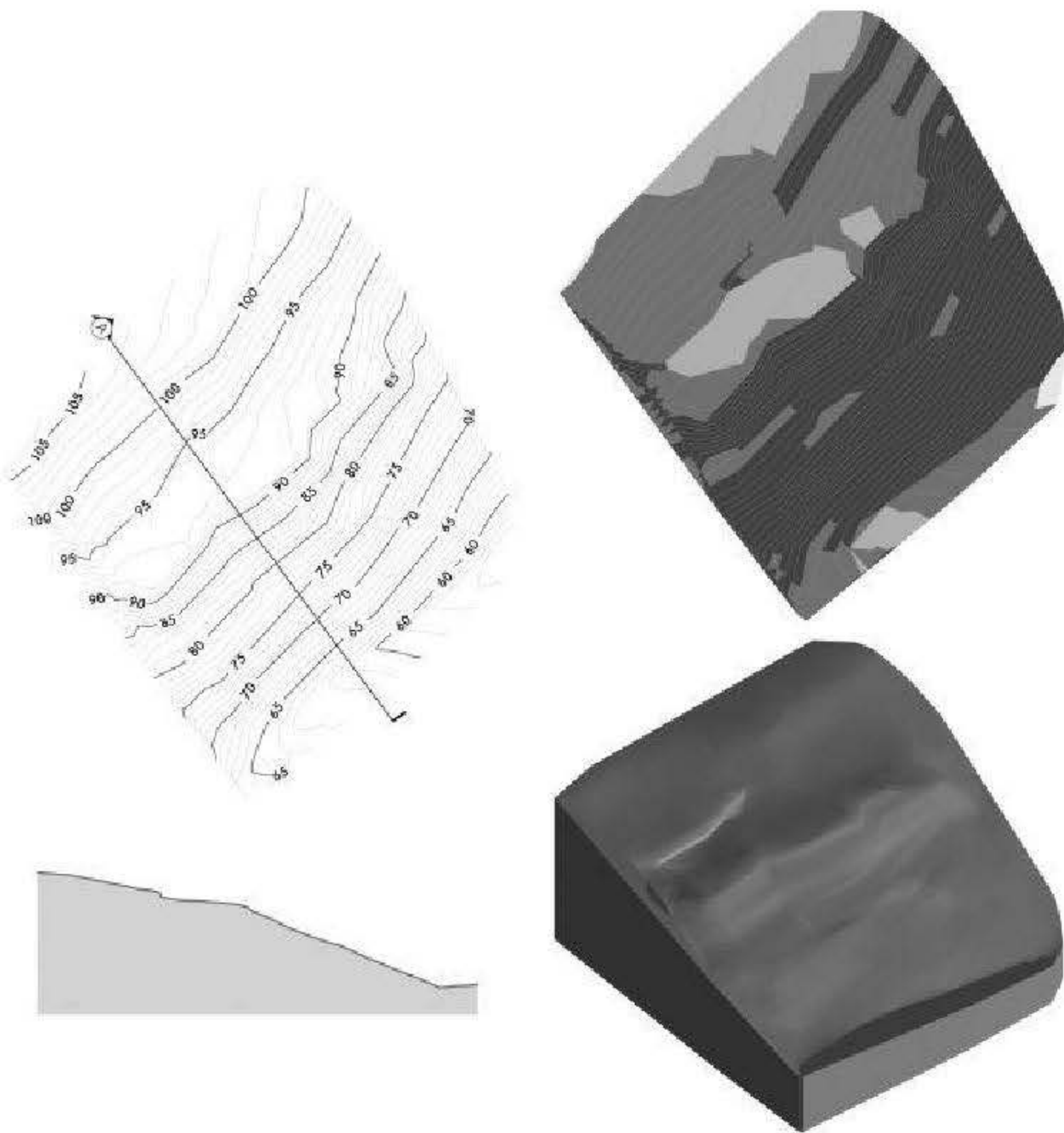
Rancho Encino Residence by Agruppo.



Once several points are established (with correct or approximate x , y , and z coordinates), there are several options for generating a survey. Most BIM software has an automated command or tool for doing so, such that site model creation can be somewhat automated. For example:

- ArchiCAD allows the importation of theodolite x , y , and z coordinates and their automatic conversion to a (static) site mesh model.
- Revit's *toposurface* command allows the automated surfacing of 3D contours to a static mesh surface. Site tools exist for adding roads and pads. The civil engineering version of Revit includes more robust tools for site creation and modification, but these are likely not in the scope of most architectural firms (see Chapter 11).
- Vectorworks Architect and Landmark can convert 3D loci (xyz coordinates) or 3D polygons to a dynamic site model. The Vectorworks site model may be modified with proposed contours, graders, pads, and roads; display existing or proposed conditions; and be analyzed for slope and cut-and-fill (Fig. 3.9).
- SketchUp's sandbox tools allow the creation of site models from contours; the site can be exported in a 3D format using SketchUp Pro, or imported directly from SketchUp to a BIM application with appropriate import function (SketchUp is so popular that most BIM software supports direct importing of SketchUp models).

FIGURE 3.9 Four views of the same Vectorworks site model, demonstrating the flexibility of view representations. Counterclockwise, starting with top left: 2D plan view with dynamic site section marker; a 2D site section; triangulated site mesh rendered smoothly; and 2D site analysis with shaded polygons indicating slope ranges.



As a last resort, the user can manually (and tediously) “stitch” a mesh as a series of triangular 3D polygons (which is in essence what the automated tools do).

From surveyed contours

The most common form of imported site information is in the form of surveyor’s files. These are commonly DWG files (Autodesk’s AutoCAD native DraWingG format) that all BIM applications can import. Modern surveying techniques consist of data points collected at spot locations via GPS equipment. These points are stored as xyz coordinates in a database, from which civil engineering software can interpolate topographical elevation contours (among BIM applications, Vectorworks Architect includes this function and can derive both 2D contours and a mesh model from discrete xyz points or 3D polygon contours). When surveyors drew contours by hand, and technology did not enable the extensive sampling of data points, 2D it seems that surveys were more irregular than they are today. The interpolation of contours from points may have contributed to more regular topographical site surveys. Archaic surveys, on the other hand, may have been less accurate, but perhaps more faithful to observed nuances of the land.

Surveyors provide either 2D or 3D contours, or both. If the contours are 2D only, they will need to be converted to 3D and each one given the appropriate elevation—which may be quite tedious for extensive site models with thousands of data points. In some software, the assignment of a z value (height) to contours may be automated, but this will still require some user involvement to assure correct elevations. Once the 3D data is complete, the site model itself may be

“built” as described above, according to the particular BIM software used.

Care should be taken that the surveyed contours do not contain too many data points. This may particularly be the case if the contours originated as smooth splines, or curves. Such contours, while seemingly desirable for their apparent accuracy, may lead to 3D polygons that are computationally too intense (slow), as discussed above. In such cases, simplify the imported polygonal contours to a manageable number of points ([Fig. 3.10](#)). Again, consider the guides provided above for the total number of data points in the site model, adjusted for project requirements and hardware and software capabilities ([Fig. 3.11](#)).

FIGURE 3.10 These are two views of the exact same (relatively low-polygon count) site models. At left is the actual geometry of the site; at right the file settings have been changed to visually smooth any angle over 70°. This smoothing is apparent only; the actual geometry does not change (hence computation times are not increased).

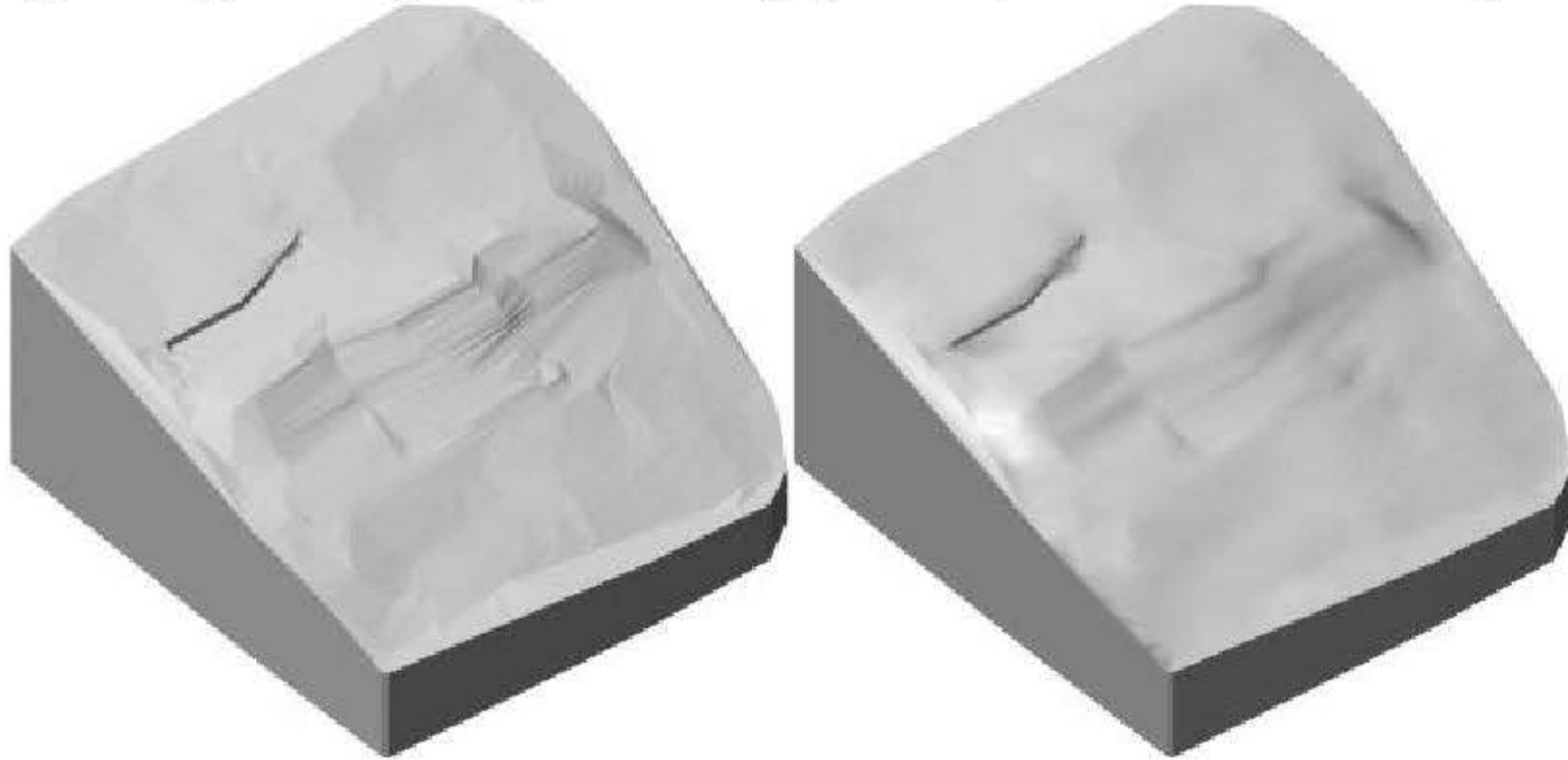
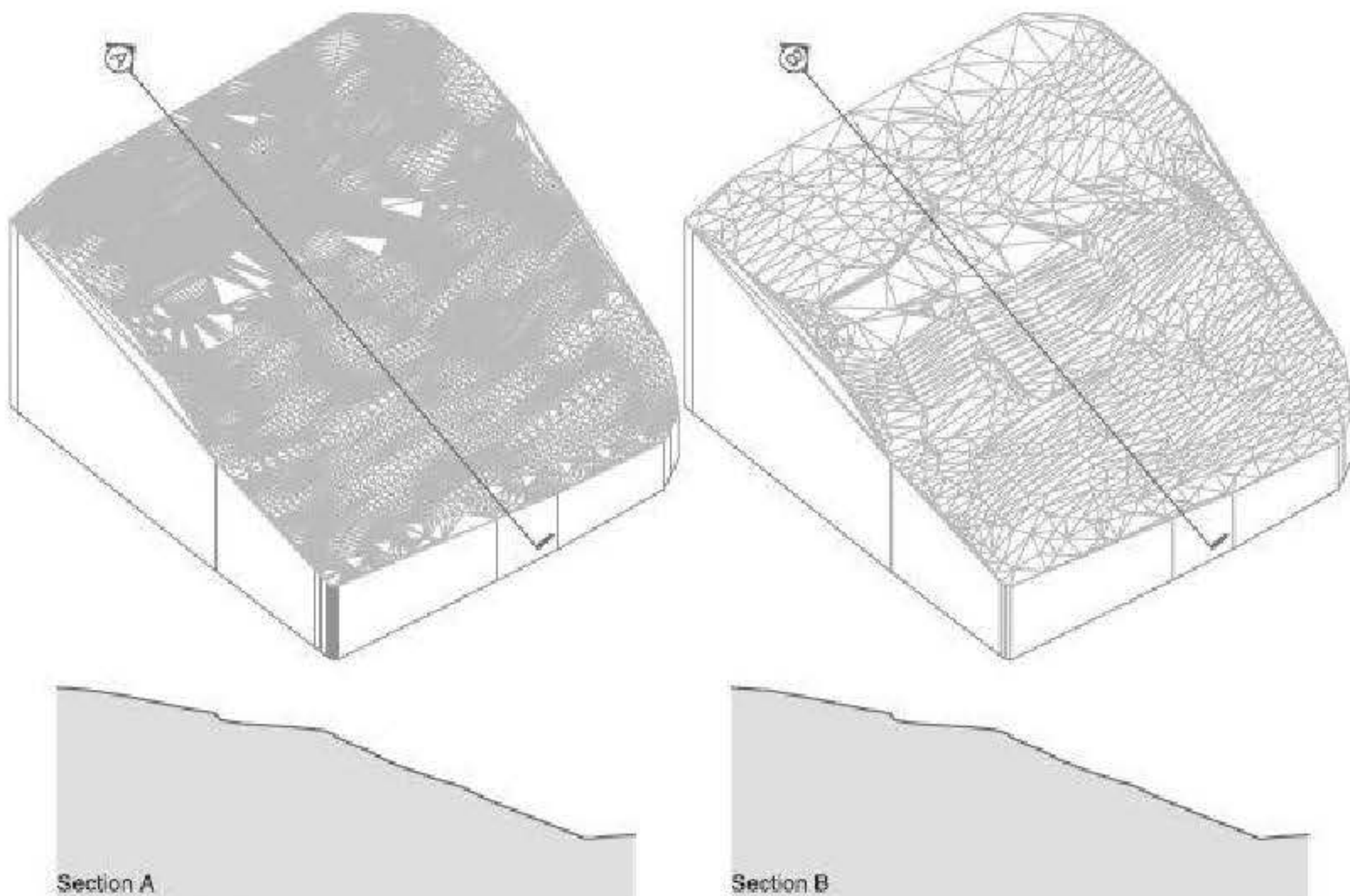


FIGURE 3.11 Two site models of the same site have very different polygon counts, with nearly 8,000 vertices at left, and under 1,000 vertices at right. Their respective site sections, however, are indistinguishable, suggesting that coarser site models are just as suitable for design and documentation, but come at a lower computational cost.



In the United States, surveyors typically use decimal feet as their default unit of length, and this is reflected in their software. Architectural BIM software, however, usually uses imperial feet and inches as the default unit. Modern BIM software will often automatically negotiate the translation of units, but on occasion due to a missed setting or error the survey will be the wrong size. In every case that I've seen, the imported site too small by a factor of 12, as feet were read as inches. This is easily corrected, either by re-importing the survey correctly, or scaling the imported file up by a factor of 12.

From aerial and topographical surveys

With the prevalence of Google maps and Microsoft Research Maps (MSR; formerly TerraServer), users have free online access to aerial photography and in many cases topographical information, albeit in a raster (pixel) format. US Geological Survey map information is available from MSR, and many Google maps include a topographical view option, albeit at a fairly small scale. Scanned hardcopies of maps or digital raster files may be used as well.

Using GIS data

For over two decades now, geography, planning, and related fields have benefitted from access to geographic information system (GIS) data and software, the geographical equivalent of BIM. In GIS, discrete layers of information represent groupings of similar data, called overlays or layers. There may be a layer for topography, another for trees (further differentiated by type or species), another for zoning classification, several for economic activity, and so forth—all associated with their relative spatial positions. Municipalities and states often have GIS files accessible for online viewing or data download, or available via disk.

To produce a useable site model, vector data are required, whether 2D or 3D; as with surveyor's files, the later is obviously preferable for TIN as it eliminates the end user's need to input contour z-coordinates or elevations. In some cases, it may be possible to download or acquire the topographical layer (contour data) as 2D or 3D DXF (Drawing eXchange Format, a more universal and archaic format) files, which may then be directly imported into the BIM application. In the case of web-viewed GIS data, where a web page serves as the user's access to the GIS data, the designer may need to capture topography as raster images (screen captures), then trace contours manually or using a

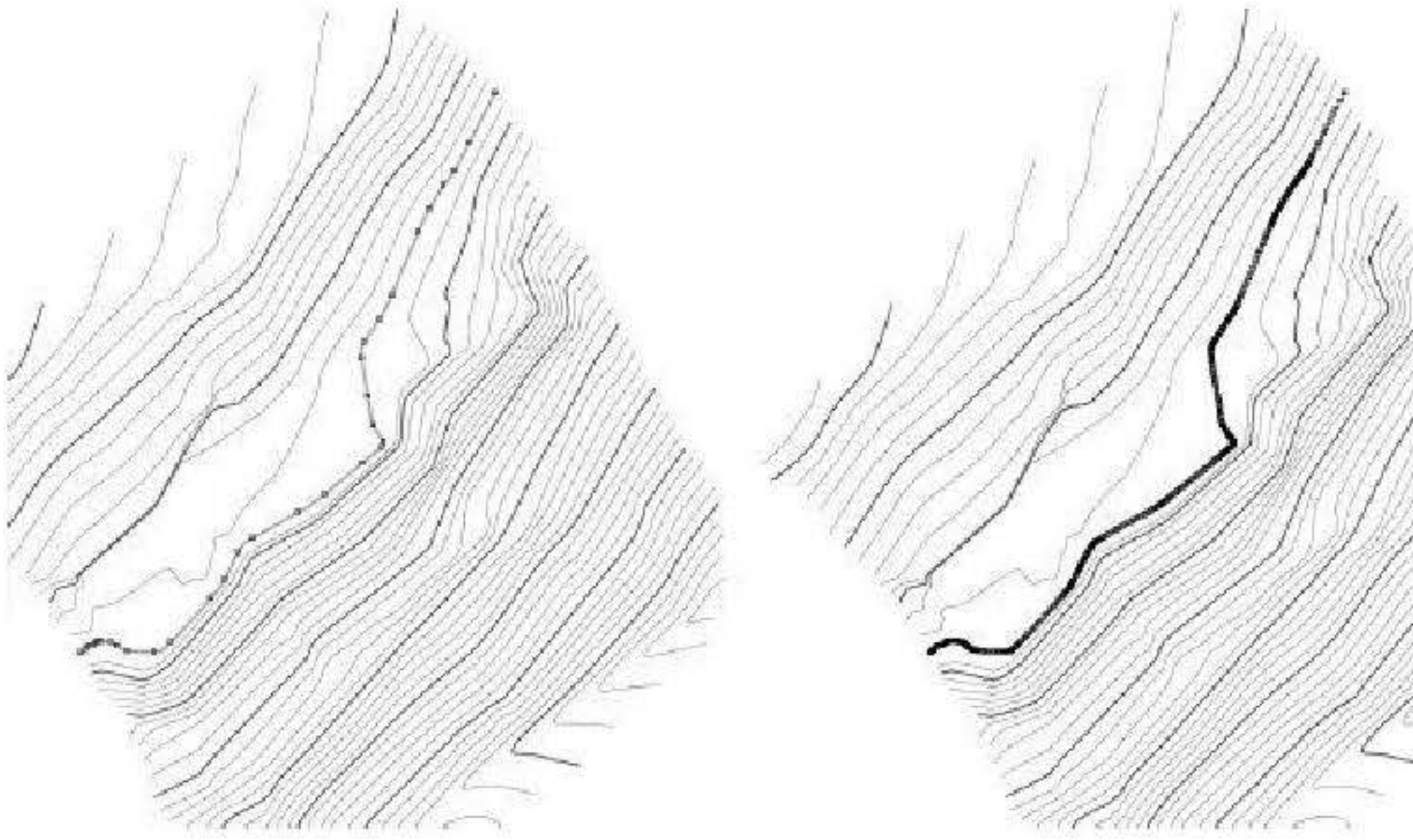
raster to vector conversion tool ([Fig. 3.12](#)). Adobe Illustrator, Vectorworks, and many other applications have this capability, resulting in vector data of varying degrees of accuracy and usability.

FIGURE 3.12 This set of two-foot contours is fairly typical of GIS data available from municipalities. In this case, over a million 3D vertices cover an area of over 636 acres; the two-acre site of interest is shown shaded, center-left.



Once the site topographical information has been gathered and imported as 2D or 3D vector objects (such as lines, polylines, and polygons) it may be processed to create the site model ([Fig. 3.13](#)).

FIGURE 3.13 The contours generating the site models from [Figure 3.11](#) appear similar to visual inspection. The contours at right are polygons converted from smooth splines; those at left are (angular) polygons. As can be seen from the number of vertices in the two corresponding and highlighted contours, the splines create many more vertices with little or no benefit.



Analyzing the site

How can BIM help inform the designer of the design implications of existing and proposed grade? How can the site be treated to minimize disturbance while supporting the design objectives? What imposed limitations and revealed opportunities for the project can BIM uncover in the combination of site and zoning ordinances?

Topographical analysis

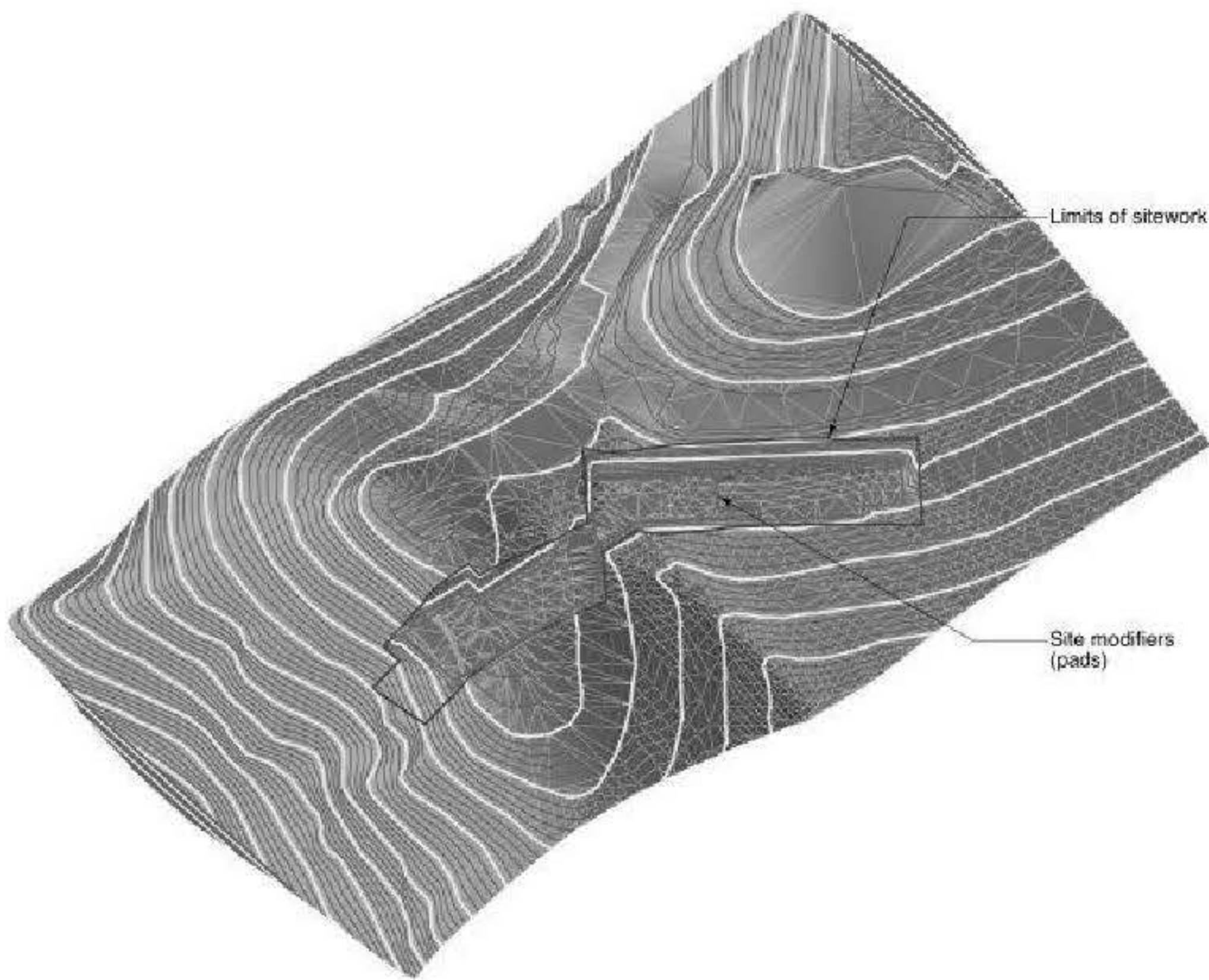
A primary function of a site model is to facilitate topographical analysis of the site. Grade obviously has a significant impact on building placement and design. Fortunately, there are a variety of ways in which a BIM site model can help the architect analyze the site for sustainable design.

Cut-and-fill analysis

In a growing number of jurisdictions, regulations aimed at promoting sustainable development prohibit the removal of soil from construction sites. Even when not a legal requirement, good stewardship of the land suggests that soil be as undisturbed as possible during construction. Removing or bringing soil to a site is also an added construction expense that may be avoided with careful design. Rather than leaving soil management to an afterthought handled during construction, the analysis of a site model in BIM can be a useful tool in designing for sustainable sites ([Fig. 3.14](#)).

FIGURE 3.14 A site model that has been modified for a building pad.

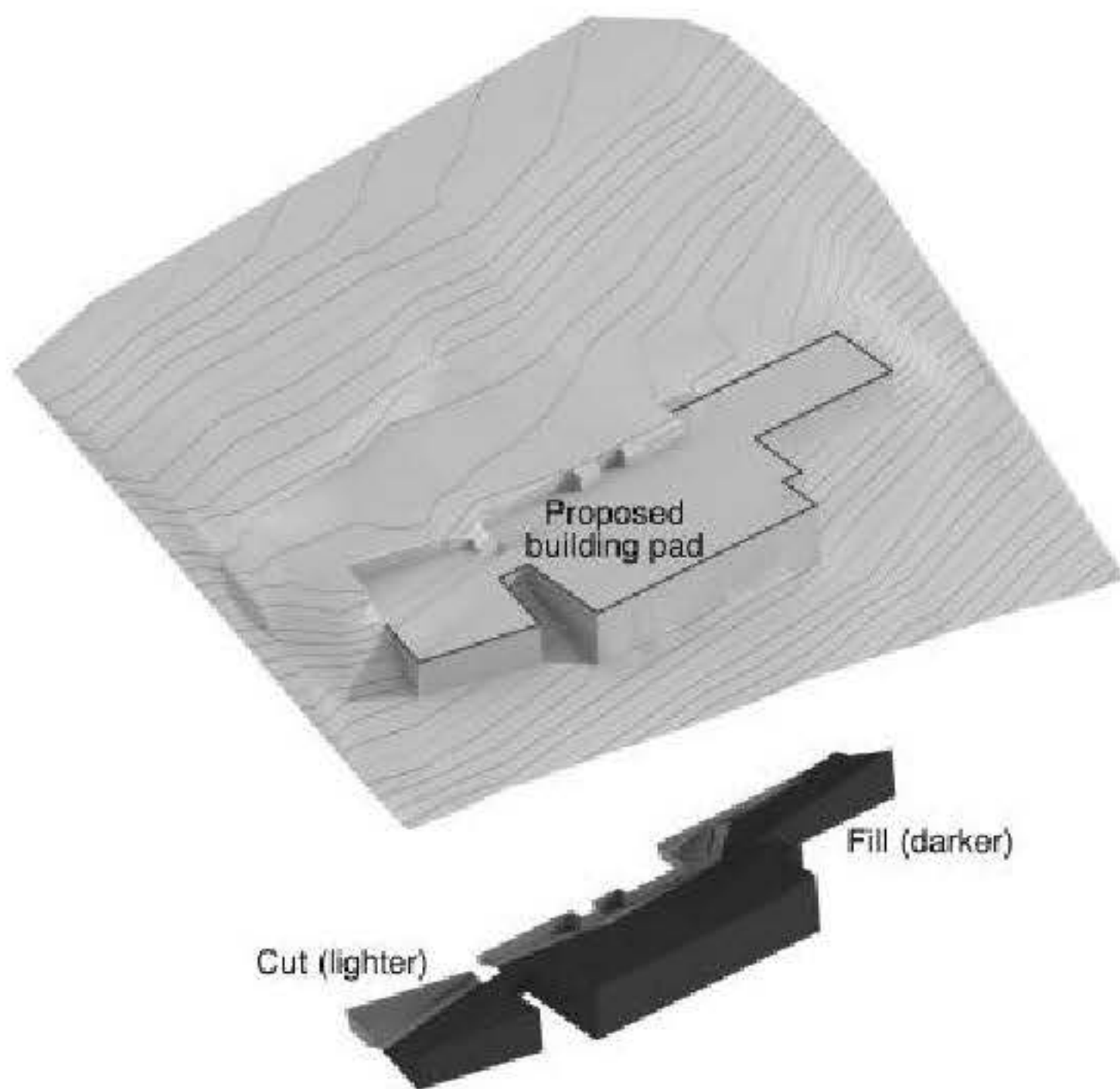
Image courtesy of Keith Guiton Ragsdale.



A cut-and-fill analysis is one way of quantifying development impact. When the BIM application allows the automated comparison of existing and proposed sites (Vectorworks Architect, Landmark), performing cut-and-fill analysis to achieve a net zero fill design is a matter of a few commands or the click of a button. Usually, however, such an analysis is the function of civil engineering software, which may not be available for smaller projects. In such cases, however, there are still options for rapid and meaningful analysis of proposed topography changes.

The designer should prepare at least two site models: one representing existing, undisturbed conditions, and another for each proposed design solution, if competing designs are to be analyzed. Each model is queried for total volume, and compared to the existing site's volume as a reference baseline; the difference in respective volumes is the cut (if negative) or fill (if positive) of the design being considered (Fig. 3.15). Competing site models may thus be evaluated.

FIGURE 3.15 More advanced site modeling software may represent cut-and-fill volumes numerically as well as graphically, as in this rendering from Vectorworks Architect.

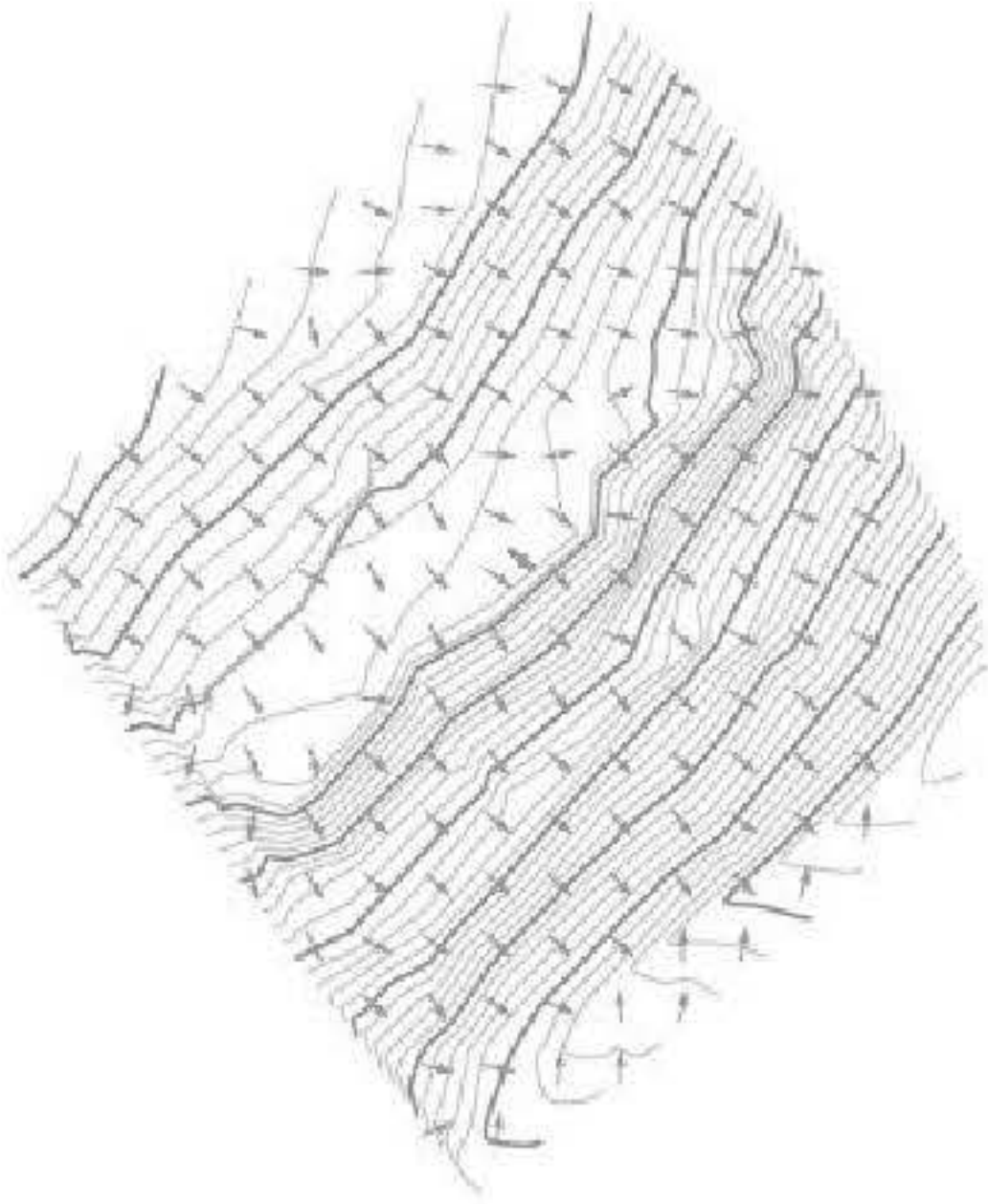


Such a method only compares net (total) cut-and-fill; for a more nuanced analysis, the designer should distinguish soil removed from that added; a site design could have a net cut-and-fill total of close to zero, but might still represent a drastic amount of earth moved. For a more refined analysis, compare a site model representing fill (alone) with the undisturbed site, as well as cut (alone) with the existing site. Here again, civil engineering software potentially used by consultants (or among architecture BIM products, Vectorworks Architect) may allow separate calculation of cut-and-fill.

Drainage analysis

Traditionally, drainage on the site may graphically be represented in plan by drawing vectors (arrows) between two given contours, perpendicular to the higher contour; the length of the arrows may be scaled to the slope. In Vectorworks (Architect and Landmark), such flow arrows may be automatically placed on the 2D representation of the site model, albeit they are all of uniform length (they show direction, but not degree, of slope; [Fig. 3.16](#)). Site drainage is discussed more fully in Chapter 9.

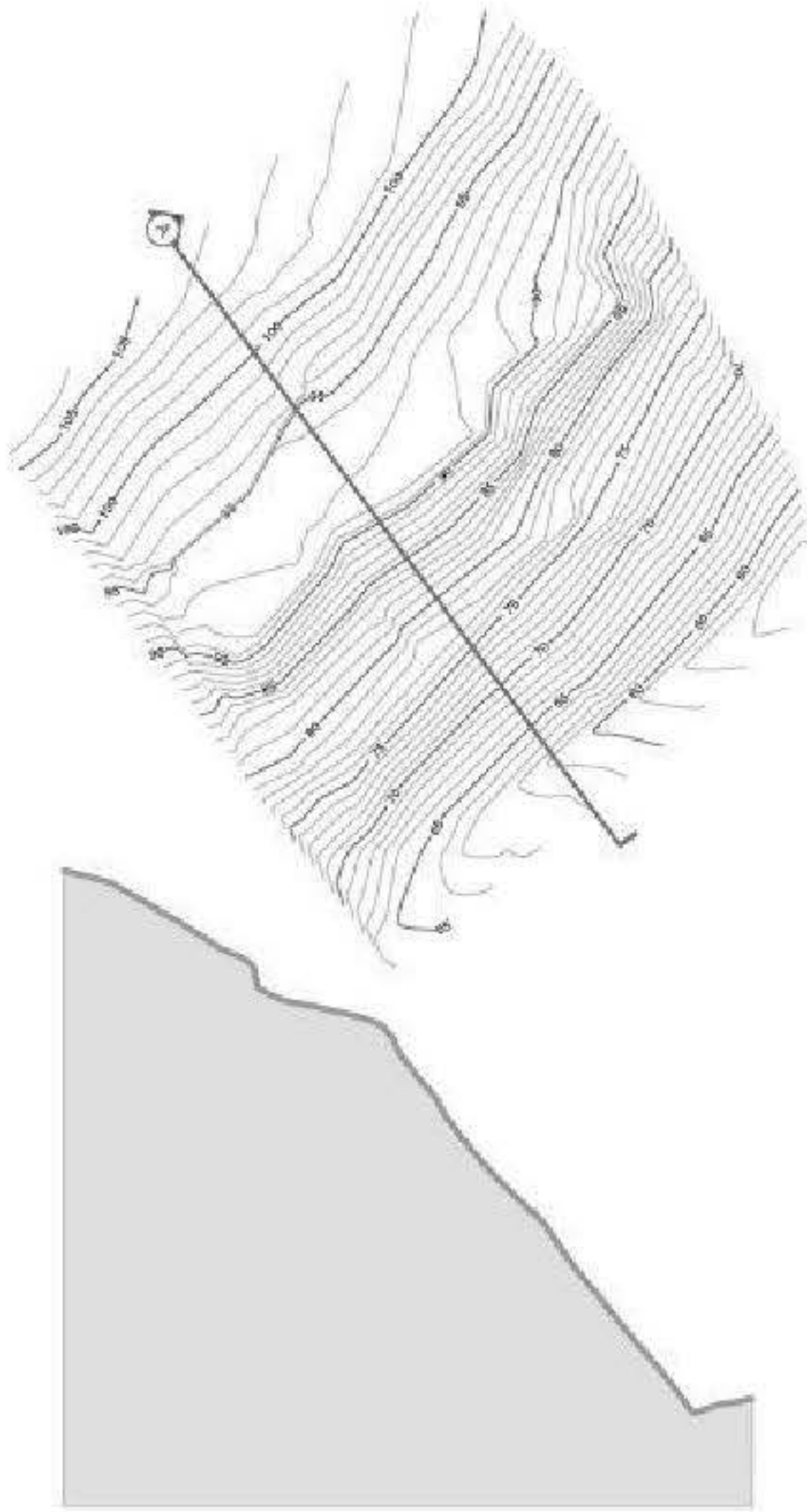
FIGURE 3.16 A site model analysis with flow arrows. The arrows in this case indicate direction, but not degree of slope (all arrows are the same length regardless of slope).



Site sections

Site sections are hardly new to BIM, and have always been an important site design tool. A section cut through the site model automates what otherwise would be a potentially laborious and error-prone drawing. For very large sites with little topography change relative to the length of the section, it may be useful to exaggerate the site section's height values (y) relative to its length values (x). Some BIM applications automate this process ([Fig. 3.17](#)).

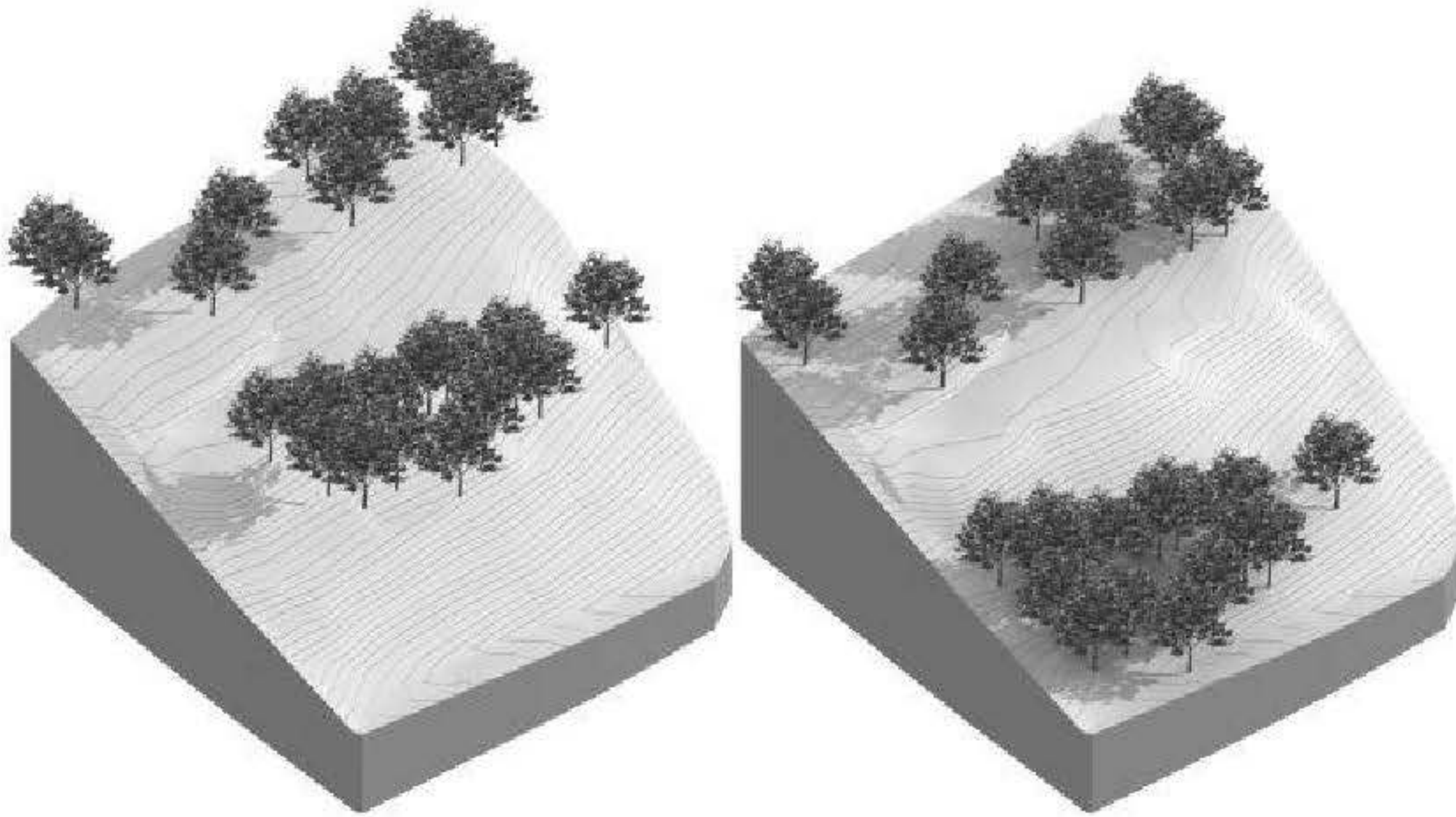
FIGURE 3.17 In a graphic convention common to civil engineering (with relatively slight elevation changes over long distances) the y -axis in this section has been uniformly exaggerated for clarity.



Float to surface/gravitate to mesh

A distinct advantage of an accurate 3D site model is the possibility of using it as a reference datum for existing as well as proposed site objects: trees, hardscape, street furniture, vehicles, entourage figures, and so on. “Floating” or “sending” objects to the surface of the site model is useful for such objects ([Fig. 3.18](#)). Various BIM applications automate this process (ArchiCAD’s Gravitate to Mesh tool, or Vectorworks Architect’s Float to Surface command, for example), saving time and helping to insure accuracy. There are some less obvious uses for this feature too:

FIGURE 3.18 Two views of the same Vectorworks site model; at left, trees have been placed at the appropriate x and y coordinates (they appear correct in plan) but “float” at a uniform and arbitrary height (z coordinate). At right, the trees have been sent to the surface—“gravitated to mesh,” in ArchiCAD terms.



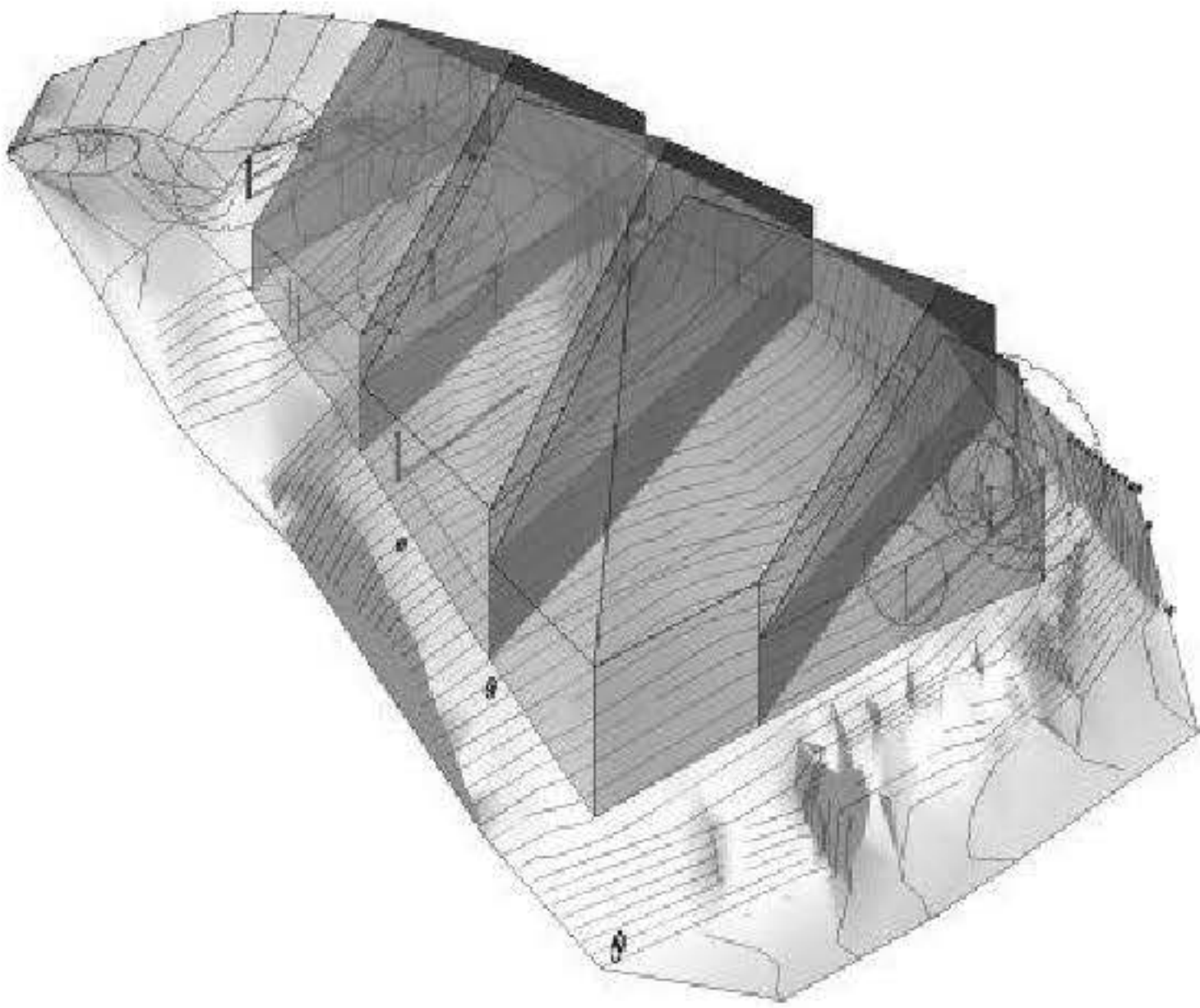
- A series of 3D points can be sent to a mesh surface, with varying degrees of density, distributed over a limited area of the site as desired. Those points can then form the basis of a more detailed site model for the limited area.
- Similarly, a group of floated 3D points can serve as the basis for secondary mesh over a portion of the site to represent a distinct material, such as a walking path. While BIM software is increasingly able to produce site-specific objects like roads and parking areas, some of those tools have geometrical limitations. For example, roads made with a road tool may be limited to a constant width. Paved areas may require complex grading that cannot be easily achieved with a mono-sloped pad. More free-form shapes, therefore, may require a floated mesh.

Buildable envelope maxima and minima

Very early in the design process, the architect must research applicable building codes, zoning ordinances, deed restrictions and covenants, comparing them to the project brief to determine the maximum (and in some cases minimum) buildable floor area and/or volume. Often these restrictions originate from multiple and overlapping jurisdictions, and it is the designer's responsibility to properly apply them. Some of these restrictions may be fairly straightforward (e.g., vertical building setback planes) and easily applicable to a 2D drawing (lines in plan); others, such as solar access rights, building "tents," or floor area ratios (FAR) may be more complex and best resolved by an intelligent 3D massing model (Fig. 3.19). Obviously, errors in zoning and restriction application can lead to unviable designs. This is especially the case early in the design process when decisions are more easily made and errors can have catastrophic results.

FIGURE 3.19 Form-based zoning codes are growing in popularity, but their application can sometimes be far more complex than their authors anticipate. Here, a site with a challenging topography and very irregular metes and bounds has a maximum buildable envelope that can only be understood and represented with a site model.

Image courtesy of Mell Lawrence Architects.



Solar rights and setbacks

Many jurisdictions impose building setbacks for most zoning classifications; those setbacks may not always be vertical, but may be angled back:

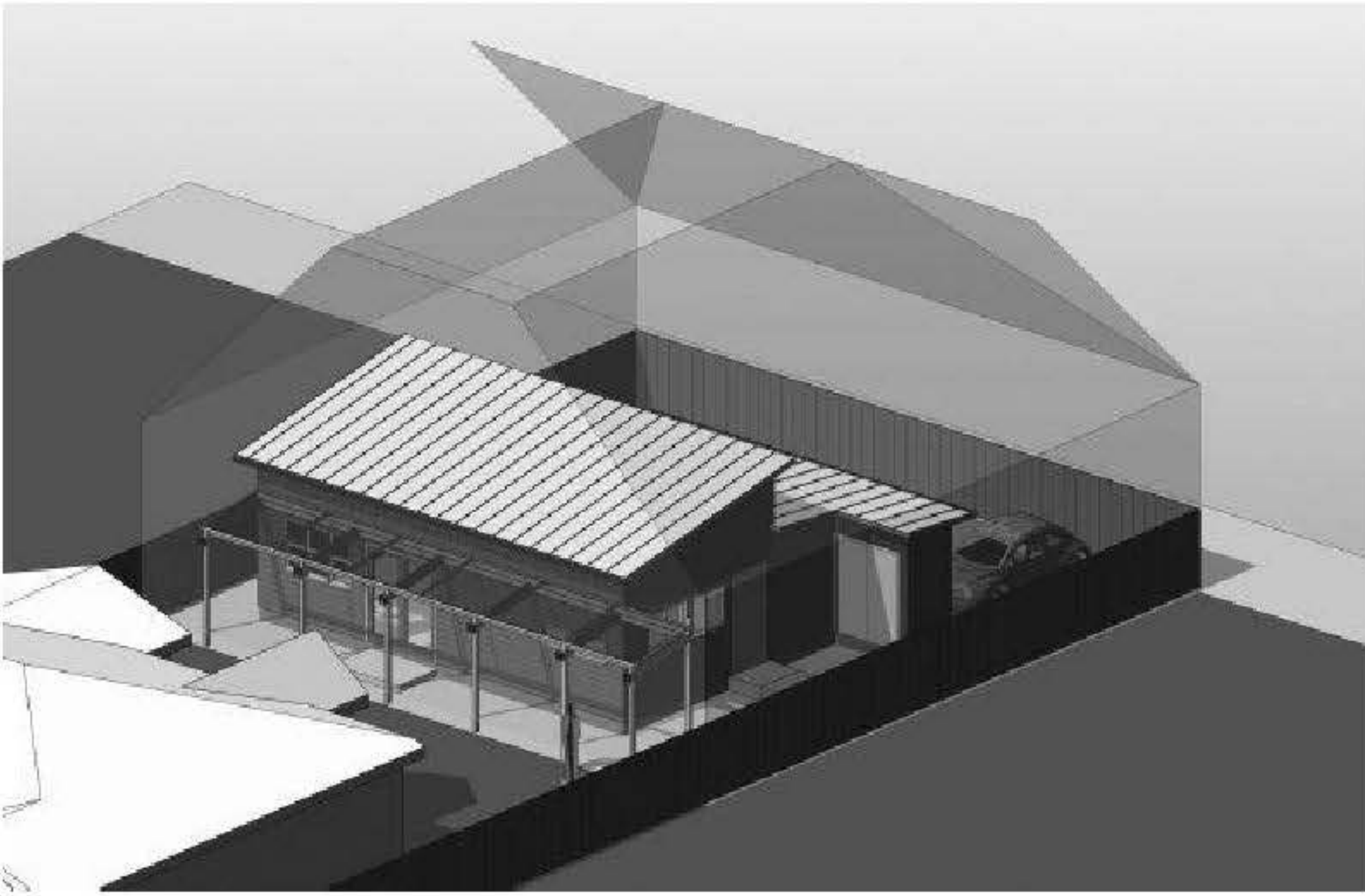
- To help assure neighboring buildings access to the sun;
- To avoid blocking views or maintain view corridors of significant natural or urban landmarks;
- To control the scale of development or impose architectural controls that encourage certain styles and discourage others.

In 2006, Austin, Texas adopted a residential buildable envelope restriction to discourage new development within the urban core that was out of scale with existing housing stock. This so-called McMansion ordinance stipulates a “building tent” bound by three planes (at the side and rear property lines) angled back 45° from the building and a vertical front plane beyond which, with some exceptions, new construction may not protrude. Given that not all residential lots are rectangular in plan, nor are they all level, there is potentially some geometrical complexity in determining whether a proposed project violates the “tent,” depending on the site.

As an example of a BIM component’s usefulness in dealing with such geometries, a graduate student of mine developed a prototype of a Revit family to parametrically generate a McMansion tent for a site ([Fig. 3.20](#)). This custom Revit object allows a project to be quickly tested for conflicts with the tent, taking into account the geometry of the particular site. While obviously no BIM application can anticipate every ordinance in every jurisdiction, the ability of users to verify compliance even with custom 3D objects is of critical importance.

FIGURE 3.20 This custom Revit family of Austin’s McMansion tent is parametrically reshaped depending on site metes and bounds.

Image courtesy of Justin Finiz Dowhower, LEED AP.



Floor area ratio calculations

Typically, zoning ordinances limit the project's **floor area ratio (FAR)**. In these cases, the maximum total building area is some percentage of the site (less than, equal to, or greater than the site area depending on the nature of the zoning classification and ordinance). In some instances, the basis area of the site may be reduced for sensitive sites. Here, a quantitative analysis of a BIM site model based on grades may be very useful in determining the amount of reduced FAR site basis (see Chapter 3).

The tabulated gross or net building area derived from the BIM model can be dynamically linked to a report, thereby allowing the designer to make quantitatively driven design decisions from real-time data ([Fig. 3.21](#)). **Incorporating FAR calculations into the BIM workflow creates very tight feedback loops.** Such a work process is more efficient and effective than designing, checking the results of the design against project limitations, and then redesigning.

FIGURE 3.21 This BIM FAR worksheet links the site to building floor plates to accurately and dynamically report local zoning and water quality compliance as the design evolves.

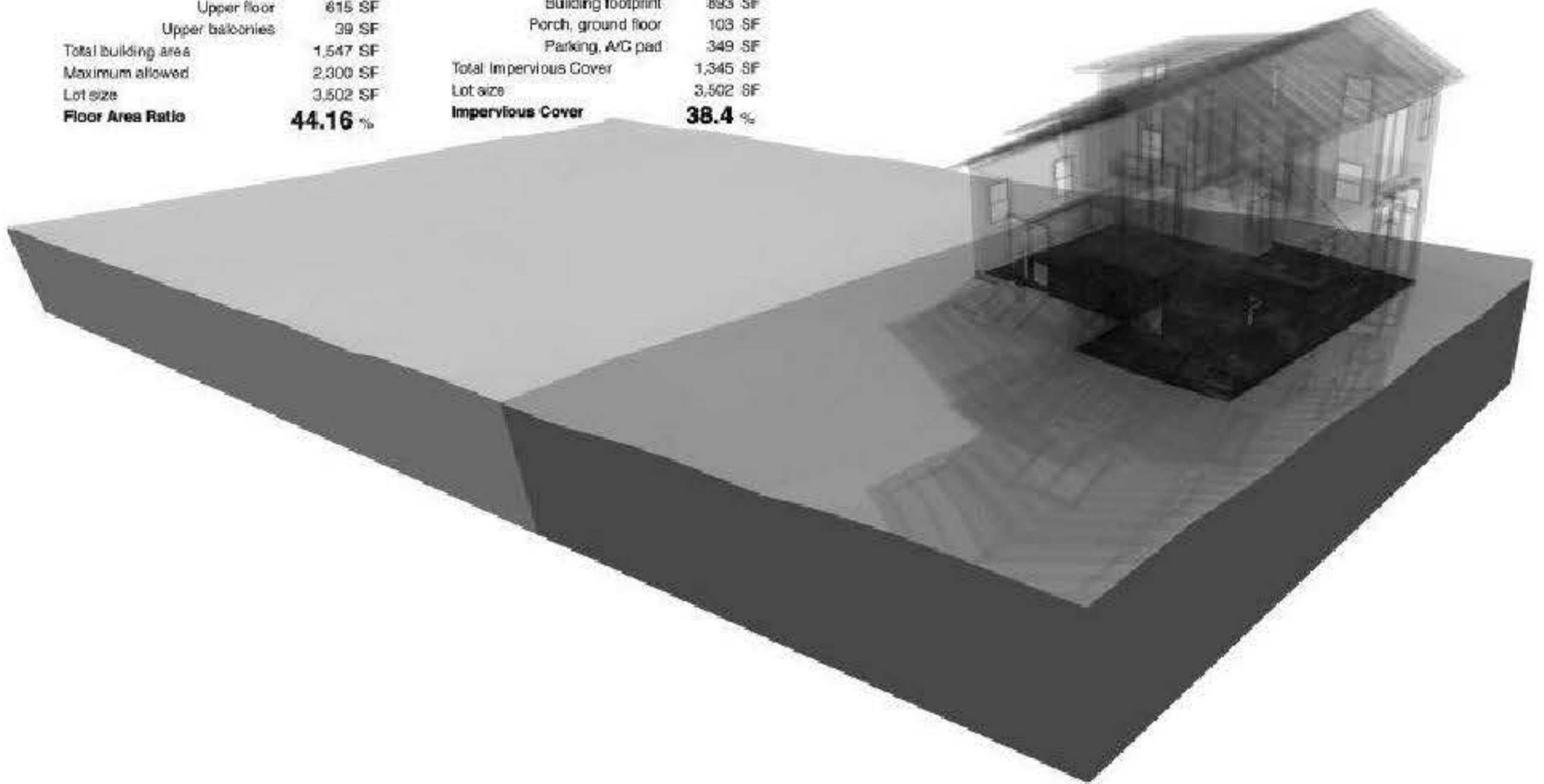
F.A.R. Calculation

Ground floor	893 SF
Upper floor	615 SF
Upper balconies	39 SF
Total building area	1,547 SF
Maximum allowed	2,300 SF
Lot size	3,502 SF
Floor Area Ratio	44.16 %

Impervious Cover

(Measured to outside face of frame)

Building footprint	893 SF
Porch, ground floor	103 SF
Parking, A/C pad	349 SF
Total Impervious Cover	1,345 SF
Lot size	3,502 SF
Impervious Cover	38.4 %

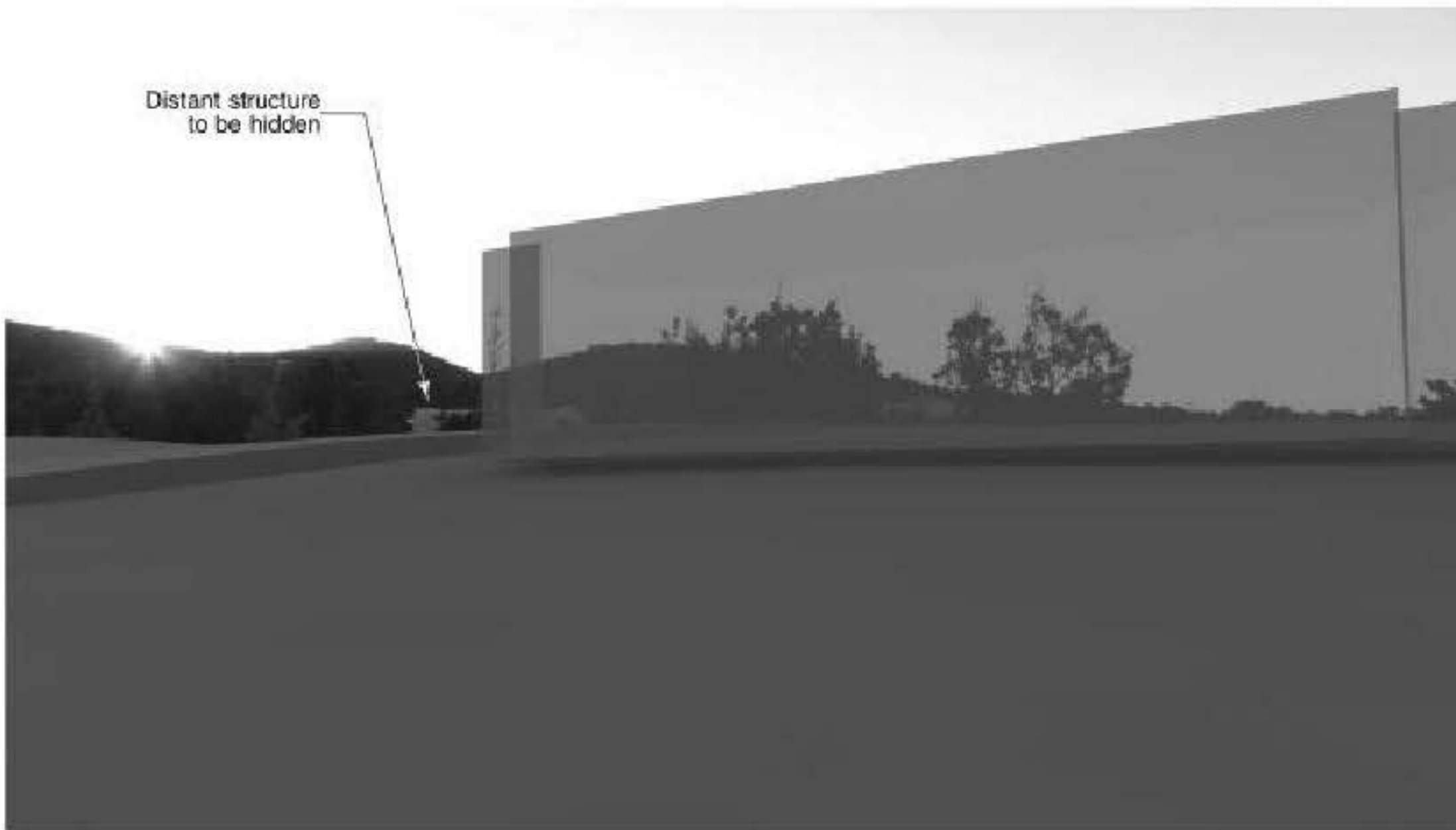


Viewsheds

An advantage of having a 3D site model that is integrated with the building model is the ability to accurately determine views of the extended site from within and around the building, in addition to the obvious benefit of evaluating the building's placement on the site. There are several techniques available, with varying degrees of complexity (and accuracy), depending on the particular features of the BIM software being used.

One such approach is to set up one or more perspective views from the point of view of the viewer. While the view may be set, the contents of that view (wall placement, window arrangement, built and natural features intervening between the viewer and the subject) may vary as the design progresses and be periodically checked from the preset view ([Fig. 3.22](#)). The subject and intervening features can be coarse, show little detail, and still be quite useful.

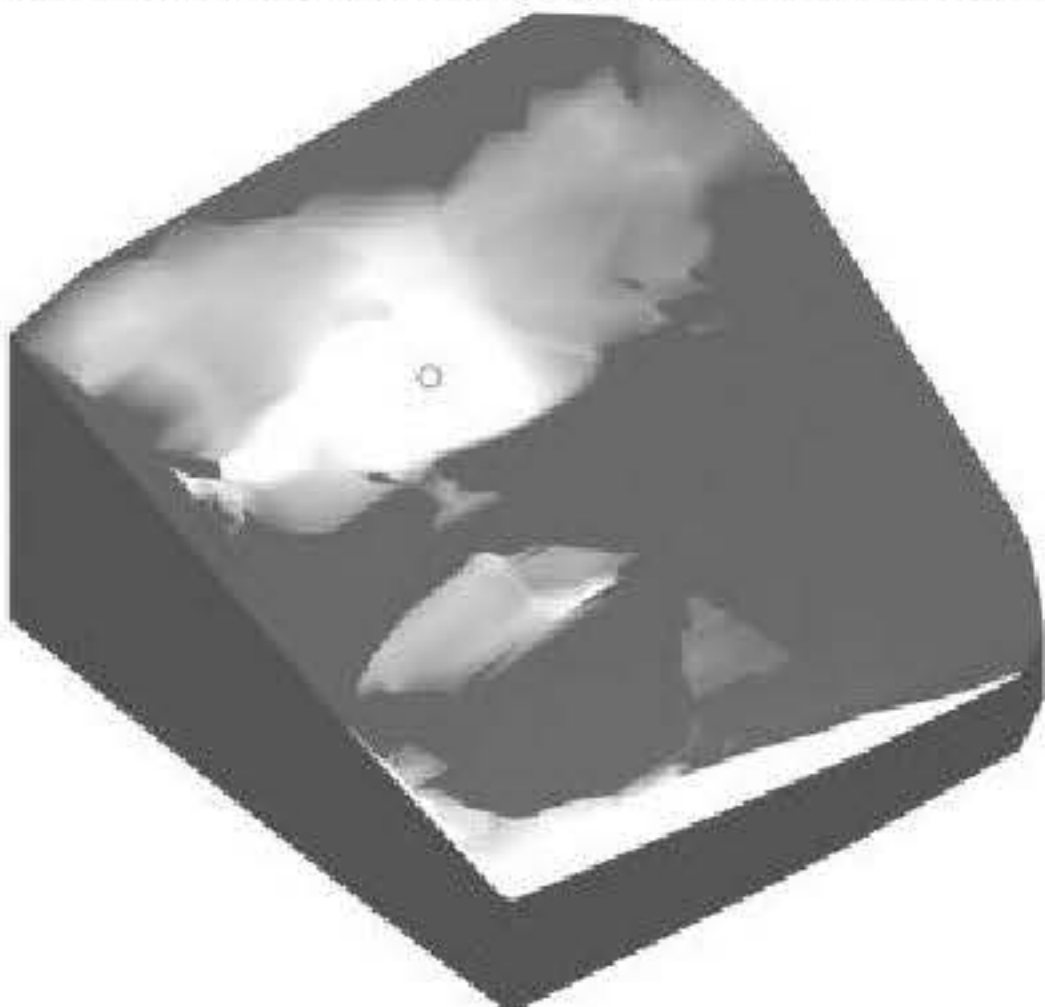
FIGURE 3.22 At the conceptual design stage, a site photo is placed within the model at the correct size and location to help evaluate the impact of proposed structures (here rendered as translucent) on desirable and undesirable views.



A raster image (e.g., PNG, JPEG) of a scene of interest may be accurately placed in 3D in the model. Some care must be taken; an incorrectly placed or scaled image will be misleading. As above, preset views are essential to effectively evaluating proposed design iterations.

A single scene or a short series of scenes are effective view determinants when the designer is concerned with a few isolated viewed subjects that are to be seen or avoided. However, this may not be a practical approach when the architect wants to assure that an entire area is to be viewed or concealed. In this case, a useful technique consists of placing a single point light in the BIM model at the viewer's location. Care should be taken to locate the light at the appropriate height, the elevation of a viewer's eyes. With the appropriate shadowed rendering option and an aerial view, the light source will illuminate all visible surfaces and objects, while those not visible to the viewer will be in shadow (Fig. 3.23). (Vectorworks uses this technique very effectively with its Zone of Visual Influence tool in its site design application, Vectorworks Landmark.) This technique may be used at any scale, for building interiors as well as for sites.

FIGURE 3.23 A simple but clever tool in Vectorworks is the Zone of Visual Influence, which can be reproduced in any model. A point light is placed at the viewer's exact xyz position; any surface in shadow is not visible to the viewer.



Case Study: House in Sonoma, California

By David Marlatt

Design firm: David Marlatt, DNM Architect

Client: Withheld

Approached from above and set on a nearly three-acre hillside overlooking the town of Sonoma, this 3,600 square foot (SF) two-bedroom house with a 650 SF garage breaks conventional notions of front yard and rear yard ([Fig. 3.24](#)). Its large overhangs protect the west-facing views from the morning sun and provide outdoor shelter adjacent to the trellis and lap pool. Located just below a ridge line, the house's long, low, north-south orientation follows existing contours, does not interrupt nearby views ([Fig. 3.25](#)), and optimizes cross ventilation in all rooms. The folded roof maximizes the surface available for photovoltaic and hot water solar collectors.

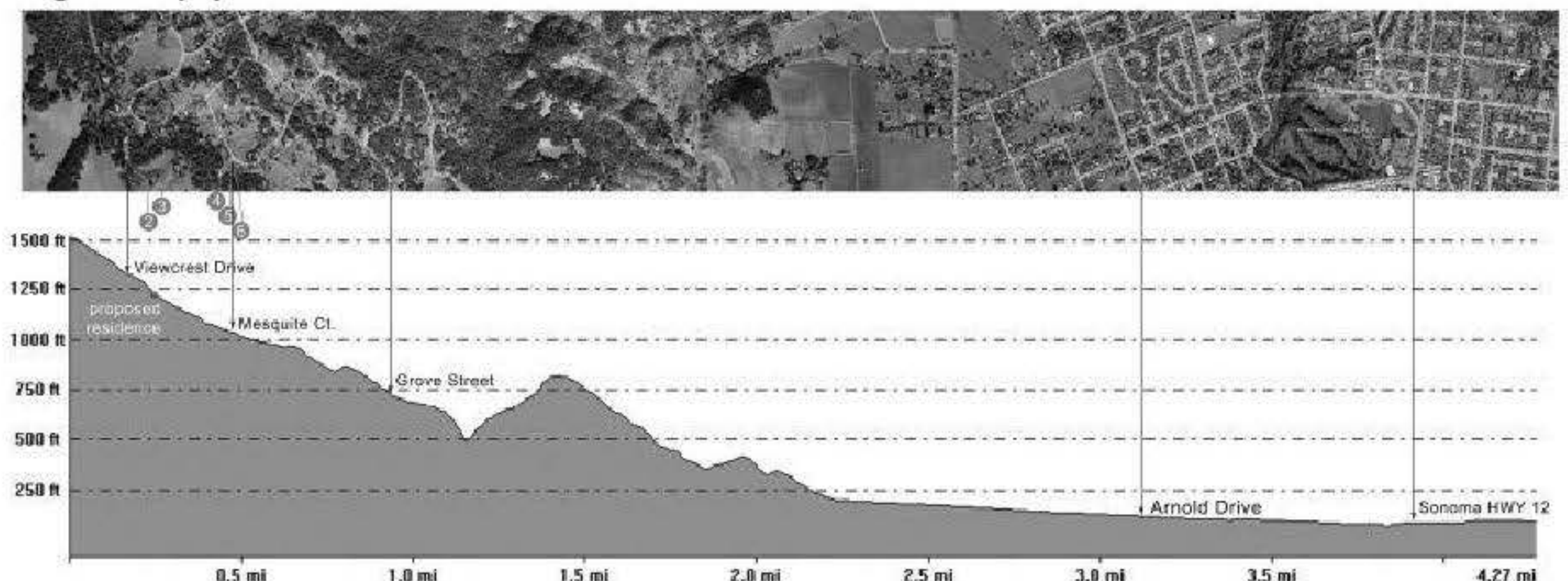
FIGURE 3.24 The Sonoma house is sited in a sloped site, with both desirable views from the house and neighbor's views to be preserved. Accurate and quantitative site analysis was one of the key tools to help ensure a successful response to the program.

Image courtesy of DNM Architect.



FIGURE 3.25 Long site sections taken of a comprehensive site model were used to evaluate the impact of the proposed design on neighboring viewsheds.

Image courtesy of DNM Architect.



Completed in the spring of 2011, the house was designed to consume net-zero energy. Heat is provided through a radiant floor slab and heat pump powered by a roof-mounted solar array. In lieu of conventional air conditioning, summer air is drawn through an insulated, naturally cool plenum below the house and exhausted through clerestory windows and vents near the roof. Every aspect of the design plays a simultaneous role in the function, aesthetics, and livability of the overall project. The house's relatively shallow depth in the north-south direction maximizes the eastward views toward the town of Sonoma and encourages cross-ventilation from the cool Pacific air that rolls in from the west in the afternoons and pours down the hill.

The foundations were formed using insulated concrete forms (ICFs) and the exterior walls were constructed using a structural insulated panel system (SIPs), providing a tightly sealed and insulated shell as well as saving significant time and labor during framing. Although the house has an eastern exposure, overhangs were studied to optimize summer shading. The exposed polished concrete slab over a metal deck pan system provides even thermal mass throughout the house to modulate temperature swings. The exterior doors and windows are thermally broken aluminum with tinted dual glazing. Other key features include a 20,000-gallon rainwater harvesting system and semi-permeable driveway paving to minimize surface water run-off ([Fig. 3.26](#)).

FIGURE 3.26 This view of the Sonoma house's entry illustrates the degree to which site topography influences and challenges the design. The driveway is semi-permeable pavement to reduce runoff.

Image courtesy of DNM Architect.



BIM software (ArchiCAD) was critical to each step of the project's success, including:

- site analysis to understand view lines and topography
- 3D visualization for the client and the Planning Department
- sun shadow and ventilation studies
- preparation and verification of the SIPs shop drawings

Even as the project progressed on the ground, the Building Information Model was updated through all of the design changes and remained "alive" on the project's dedicated project Web site hosted by the architect.

Working from 2D survey data and publicly available topographic information, we constructed a 3D model of the site and surroundings and analyzed the view shed from a major road in the valley below. This helped establish that the house would not be within the Sonoma County view shed and therefore avoided a higher level of scrutiny by the county planning department. Understanding and controlling view corridors was equally important to the client, who desired to optimize the major view of the town of Sonoma to the east without obstructing the neighbor's view uphill to the west. In addition to view analysis, the 3D site model helped us understand prevailing wind patterns and design the house for optimal cross ventilation ([Fig. 3.27](#)). Using the 3D model and Ecotect, the design was analyzed to insure that all major spaces received ventilation and dead spots or eddies were eliminated.