**Beverly Willis, FAIA**

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| **Date:** | 1971–72 |
| **Client:** | Willis and Associates, Inc. Architects and Planners |
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COMPUTERIZED APPROACH TO RESIDENTIAL LAND ANALYSIS

CARLA,or Computerized Approach to Residential Land Analysis,is a proprietary software program developed in-house by Willis and Associates, Inc. Architects and Planners (Willis) in 1971. It was publicly introduced through marketing brochures in 1974 as the logical application of “space age” technologies, designed to address the complexities of large-scale suburban land development facing builders, developers, and environmental planners at the time.

Tumultuous currents of social and ideological change fueled the developments of the 1960s and early 1970s. In 1969 the United States succeeded in landing astronauts Neil Armstrong and Edwin Aldrin on the Moon, where they completed the first lunar walks. New technologies advanced space exploration and opened many other new frontiers. At the same time, however, socio-economic pressures plagued the nation, giving rise to record rates of inflation, an energy crisis, and other environmental concerns. Two building depressions nearly paralyzed the construction development market. As architectural historian Leland Roth notes, “The result was a serious business recession during the 1970s that decimated,if not closed, many architectural offices.”**[[1]](#footnote-1)** Willis and her associates recognized the need to find a niche where architectural work was still in demand.

Where others saw limitations, Willis saw opportunities, and she took a series of calculated risks that positioned her firm to succeed and grow in a climate where others failed. During the 1970s, large-scale, multi-acre, multi-family condominium communities emerged as a new concept. Prohibitive expense was associated with building on hillsides versus building on flat land. She urged her firm to undertake the planning and design of environmentally rational, multi-housing development projects on challenging sites, supported by use of the newly developed computer.

Developing software for private use in the early 1970s was an ambitious and expensive venture. At this time private use of computers was limited to fairly large corporations. Universities such as Harvard, MIT, and Stanford housed their own Computer Research Labs to support hardware and software research. The word “computer” was relatively unknown to most of the public. Firms like Microsoft, Apple, and Google did not exist, nor did desktop computers, portable reading devices, or smartphones. Running on punched cards and paper tape, the mainframe computer had not yet entered mainstream American culture.

During World War II, a teenaged Willis served as a pilot; at seventeen, she was a Lieutenant in the Civil Air Patrol. In conversations with military pilots she had learned of a computer mapping program that drew bombing site perspectives. She decided to locate this software to evaluate its application to land planning. She found the program at the Kansas Geological Survey department (KGS) at the University of Kansas.[[2]](#footnote-2) The KGS maintained a series of programs originally developed during World War II that were later adapted for industrial use by American oil companies. By 1971 it had also programmed a mapping and contour program called SURFACE II.

Willis was interested in SURFACE II and how she might use it, but because the University of Kansas is a public, non-profit institution, it could not sell the programming directly to her (or to any private individual) for commercial use. However, because her interest in applying the software to land development and urban planning complemented a potential research direction the KGS wished to explore, the two parties were able to reach an agreement.[[3]](#footnote-3) The collaboration proved to be a success. The KGS refined SURFACE II’s programming to include the production of precise drainage map algorithms, slope analysis, and cut and fill diagrams. The new version was named SYMAP.

Although SYMAP provided land drawings, it did not provide the land planning required to determine the type of housing that could be placed on the land, nor the exact location or cost of the buildings. Willis contacted the Stanford Engineering department, which explained that first~~,~~ Willis would need to provide a system analysis of the design flow of land planning. Willis then turned to the dean of the Harvard University Graduate School of Design (GSD) for suggestions on how to get this done. The dean referred Willis to Eric Tiescholz, associate director of the Harvard Laboratory for Computer Graphics and Spatial Analysis, whom she retained as a consultant.

Tiescholz reviewed the SYMAP development by KGS. He also recommended she hire Jochen Eigen––a GSD student from Germany who knew how to code––to help fashion the design aspect of CARLA. Eigen had just completed his first year of a two-year Masters program in the spring of 1971. The school’s Dean agreed to let Eigen finish his second year and complete his degree by working with Willis’s firm in San Francisco. After Eigen developed the systems analysis of land planning work and interviewed the firm’s professional staff, he wrote the software program for CARLA that allowed the mapping contour programs and Willis’s planning unit concepts to interface.

CARLA consisted of multiple steps. Data extracted from traditional analog topographical maps, geological soil analysis, environmental site assessments, and marketing information was manually input into the system, three software programs manually interfaced with SYMAP and planning unit concepts.[[4]](#footnote-4) After completing these steps, a variety of hypothetical planning proposals could be made.

Once the site’s contours, derived from topographical maps, were digitized into CARLA, the computer could generate contour perspectives of the site from any point plotted along an x–y axis. In addition, CARLA could plot natural drainage patterns and conduct slope analyses, as well as identify areas requiring cut and fill and create “before and after” site perspectives. Areas of common building suitability were identified manually, based on the plotted maps.

Using the CARLA grid as a template, multiple planning unit concepts were introduced and profiled against the site’s characteristics. CARLA was then able to determine how many building units, in what variety, and of what cost a given planning concept could successfully integrate into areas of common suitability within the site. By repeating these tests for the different planning unit concepts, the most environmentally and economically acceptable configuration for the site was determined.

The computer graphic information reports were represented either in map form (as site perspectives or contour maps) or as a sequence of numeric values organized within a matrix. Both allowed the architect to identify the optimal pairing of land and planning concept. This work then became the basis for manually drawn presentation materials that were used to introduce the client/developer to the proposed designs.[[5]](#footnote-5) In many cases, a site’s topographical map was used as the base, onto which a variety of contour studies were over-laid by hand using transparent materials.

In 1972 Alpha Land Company gave Willis and Associates its first opportunity to use the CARLA software by commissioning it to plan and design the Pacific Point Condominiums in Pacifica, California. The steeply sloping site sits on the San Andreas Fault, and only a small percentage of it was considered buildable. It was CARLA’s challenge to locate that buildable land and to identify what type of buildings would make a development on the earthquake-prone site economically feasible.

CARLA facilitated the analysis and integration of diverse environmental conditions that deeply effect planning and design decisions. It also evaluated the impact of these decisions on overall project performance and cost. This work was born of Willis’s deep environmental ethic and her appreciation for the functional relationships between “natural” forces and the built environment. She believed that environmental design professionals tended to view the environmental system myopically, focusing only on elements of the system relating to their personal sphere of specialization. However, each discipline has an impact on the others. Myopic viewpoints sometimes work against each other, and this often hampers environmental protection rather than enhancing it.

Willis accomplished her work during the golden years of the American environmental movement, at a time when the devastating effects of poor regional planning were first being felt across the United States. Her work contributed a pioneering tool and original methodology to the emerging discipline of Systems Ecology and integrated the natural sciences with the design process.

While all construction impacts the environment, new communities occupying many acres exert a significant impact, not only on a site’s natural ecosystems but also on neighboring communities’ infrastructure. The site’s environmental variables such as topography, natural drainage, slope, and soil composition, together with its engineered elements such as roadways, schools, and recreation facilities, must be addressed comprehensively, accurately, and efficiently so that development can proceed responsibly and harmoniously with the surroundings. The goal was to devise a custom planning strategy that honored the site’s natural ecology by moving less earth, thus helping to save the natural environment.

When the National Environmental Protection Act was passed in 1969, California was one of a few states that imposed further, more stringent regulations, including the mandatory filing of Environmental Impact Reports (EIR) for projects exceeding four units of housing. This directly impacted Willis’s area of specialization. She immediately recognized the failure of both federal and state agencies to issue any supporting literature outlining the new guidelines or identifying the regulatory criteria. The legislation was ambiguous and left too much latitude for interpretation, thus limiting its effectiveness. As chair of the Federal Facilities Council (ca. 1974­–78), Willis was motivated to help set meaningful standards to ensure environmental preservation and the long-term integrity of future building projects. She took on a leadership role in addressing the national EIR inconsistencies and helped U.S. government agencies in developing systematic evaluation standards to evaluate compliance. In addition, Eigen drafted an environmental evaluation system using four matrices that compared land development strategies and rated their impact on environmental factors. At the same time, he developed a systems analysis of the various environmental relationships themselves.[[6]](#footnote-6) Through these activities, Willis and her firm gained mastery in understanding the various regulatory codes, and this expertise would prove to be a valuable asset for her firm and her clients.

Willis’s primary motivation in developing CARLA was to create minimal-impact sustainable housing, through environmentally sound decision making that supported the efficient use of land, appropriate allocation of density, and reduced reliance on excavation and grading. But CARLA’s development also produced other significant benefits. Between 1971 and 1974, the amount of time required to fully develop a new community nearly doubled. Eugene Rosenfeld, president of the construction firm Kaufman & Broad Inc., noted in a real estate column that “consumerism, environmentalism, and energy related difficulties [had] cumulatively re-written the rules and lengthened the time frame for housing production in the U.S.”[[7]](#footnote-7) CARLA devised development strategies that limited excavation demands on a proposed site, significantly reducing labor and materials usage. This allowed developers to cut their costs by 20 percent and build apartments or townhouses more quickly, further optimizing profits.

Willis and Associates, Inc. and other rare architecture and engineering firms recognized the computer’s potential as a tool facilitating financial evaluations and administrative tasks. Reynolds, Smith and Hills of Jacksonville, Florida produced management software called A-Es, which were designed to organize an array of financials; when comprehensively analyzed, it could help identify a successful development investment strategy.[[8]](#footnote-8) The initial creation of computer-aided design (CAD), however, has a longer, more complex history, with innovations introduced at each stage in its protracted development.

Quantitatively, CARLA allowed Willis and Associates to produce during a twenty-day period what traditional methods required other architects and planners four to six months to produce. The firm was able to generate not just two or three viable proposals but 20 or 30, thereby multiplying its capacity nearly ten-fold. In 1973, *The San Francisco Sunday Examiner* printed the article “Computer Moves into Land Studies” emphasizing CARLA’s efficiency and cost savings potential. It noted that CARLA could process “500% more information in 400% less time and at 40% of the cost generated by utilizing the more traditional methods.”[[9]](#footnote-9)

In addition, CARLA was able to accurately project development costs within a very small margin of error (roughly 3 percent), providing the developer or investor with a concept plan that nearly perfectly matched its financial objectives. CARLA’s speed and degree of accuracy allowed the builder to start construction more quickly, with less land development costs. This was a key consideration in the 1970s, when inflation rates were constantly rising and any delay could potentially introduce a significant increase in costs.[[10]](#footnote-10) The potential condominium buyer also appreciated the savings CARLA helped to realize: on one project, this equated to $2,000 per unit.

Qualitatively, CARLA achieved better, more cost-efficient, environmentally sound multi-housing developments. In addition, it advanced the profession of architecture by providing architects and land planners with a consistent information-structuring tool that allowed the professional to consider and compare multiple fields of information, in combinations that far exceeded the scope of traditional methods. After CARLA’s phased process identified an optimal planning concept, the architect was then free torefine the plan further, initiate scale drawings, and address the more creative concepts associated with the project. As an organizing information grid, CARLA also became instrumental in addressing census tract data and helping to define the best geographic site for potential development.

While many firms suffered financially during the 1970s, Willis’s firm grew in size. Amongst a larger staff, its principalsincluded Beverly Willis, FAIA,President**;** David Coldoff, AIA, Executive Vice President; and Charles Rueger, AIA, Associate Designer. Jochen Eigen was now vice-president of research and development. The firm experienced an increase in activity, with 1975 billings generating an estimated $2.2 million. CARLA also met with great professional and academic acclaim. Willis was asked to give presentations about the computerized land analyzing program at many conferences, and she taught the CARLA system for two summers at the Harvard Computer Laboratory.

**References:** partial listing of articles organized by date.

**1972:**

*Economic Probes, Key to Developer’s Success,*

Building Design and Construction, The Magazine of Commercial and Industrial Building. A Cahner’s Publication June 1972 no credit

**1973:**

*Savings seen in Planning by Computer.* Part VI. Sept 2, 1973. Los Angeles Times.

*Computer Moves into Land Studies*. S.F., Sunday Examiner& Chronicle 9-9-1973

**1974:**

Dick Turpin. *Condo-Mania Keeps Growing****,*** , April 7 1974, Los Angeles Times.

*New Land Planning Techniques Change Condominium Approach*, April 11, 1974. San Francisco, California Daily Pacific Builder.

*Condominium Market Impact: Space Age Land Planning*April 14 1974Las Vegas Sun, No Credit

Lon M. Carlston, Tribune Real Estate Writer, *New Approach Offers Savings*, The Sunday Tribune Real Estate Section. April, 28.1974.

*A Boost from Computers, Marketing Information Retail*, November 1974? (Received stamp 1974)

**1975:**

Sidney P. Allen, Financial Editor. *Land Planning, CARLA Races to Get Job Done, The Chronicle,* September 7, 1975.

1. Roth, Leland M., *A Concise History of American Architecture*, Harper & Row, New York, 1979, pg. 475. [↑](#footnote-ref-1)
2. This initiated a five-year collaboration between Willis and the department, represented primarily by Chief of Geological Research John Davis and Systems Analyst Robert Sampson. [↑](#footnote-ref-2)
3. Described as a collaboration, the relationship between Willis and KGS was funded with donations from Willis and Associates to the University of Kansas in support of the KGS’s ongoing research. A 1974 Willis and Associates brochure describes CARLA as a proprietary service of the firm, and 1974 Aliamanu reports generated by CARLA reference Beverly Willis and Associates’ copyrights based on work by Willis, not by KGS. While secondary to the topic of innovation, this information does provide interesting insights into the necessary negotiation of public and private interests––negotiation that certainly continues to fuel research and development today. [↑](#footnote-ref-3)
4. Willis and Associates developed over time a library of more than 4,000 planning units from which they could choose, in addition to drafting new ones. [↑](#footnote-ref-4)
5. This is mentioned in greater detail in the CARLA binder of accumulated press clippings in the Beverly Willis Connecticut Collection. It may, however, be interesting to compare some of the Hayward studies to the later Aliamanu Valley Community, Honolulu, HI 1978 studies to demonstrate the software’s evolution and more refined graphic capacities. It is interesting to note, however, that even up to 1976, Willis and Associates continued to manually introduce the titles and legends, as indicated in a letter from Willis to Davis at the KGS, dated March 17, 1976. CARLA Collection, Summary Section, Beverly Willis Collection. [↑](#footnote-ref-5)
6. See Sharon Lee Ryder,“Environmental Impact: Getting at the Issues,” reprinted from *Progressive Architecture*, June 1974 (New York: Reinhold Publishing Company, Inc., 1974). [↑](#footnote-ref-6)
7. Eugene Rosenfeld, quoted in Lon M. Carlston, “New Approach Offers Savings,” *Sunday Tribune*, Oakland, CA, April 28, 1974, Real Estate section. [↑](#footnote-ref-7)
8. “Economic Probes, Key to Developer’s Success, Enhanced by Computers from Building Design and Construction,” pamphlet, published by *The Magazine of Commercial and Industrial Building*, June 1972. CARLA Project Collection Binder, Beverly Willis Collection. [↑](#footnote-ref-8)
9. “Computer Moves into Land Studies,” *San Francisco Sunday Examiner & Chronicle,* September 9, 1973. CARLA project binder. Beverly Willis Connecticut Collection. [↑](#footnote-ref-9)
10. A good example of CARLA’s capacity to run a number of initial site profiling reports is illustrated by a group of three tests run on the Hayward project over a 20-minute timespan. See CARLA Collection, [↑](#footnote-ref-10)