Planning Tools for the Santo Domingo Pueblo

Guidelines for Future Housing Rehabilitation

An Interactive Qualifying Proposal submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of the Bachelor of Science.

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Abstract

This project focused on developing tools to help the Santo Domingo Pueblo's rehabilitation efforts inside its culturally vital Historical Village. The Santo Domingo Tribal Housing Authority (SDTHA) is in the process of creating and implementing a five year housing renovation plan to improve some of the visibly deteriorating homes. Our team was provided with the data of building surveys taken in the past year from which we we created and organized multiple GIS maps showcasing the condition of all the surveyed buildings. From those maps, we created visual representations in order to present the need for renovations to the Tribal Council. In addition, we digitally modelled the entire Village and 3D printed portions of it to use in a topographical model at SDTHA for presentation purposes. Finally, we created a visual rubric to more consistently evaluate buildings in future surveys, a system to assess which homes are most in need of rehabilitation, and example five year plans that utilizes these systems.

Executive Summary

The objective of this project was to assist the Santo Domingo Tribal Housing Authority (SDTHA) and Santo Domingo Tribal Planning Department to develop planning tools that will help create and maintain a long term plan for housing rehabilitation in the historic Village of the Santo Domingo Pueblo. While culturally rich, the tribe has faced several economic and environmental challenges in recent history. Upwards of 25% of tribal members live below the national poverty level, with an average per capita income of $6,038 in the 2000 census. The Santo Domingo Pueblo needs a planning strategy for rehabilitating existing houses in disrepair as well as developing new areas within the village that account for future issues, such as hail or flooding. Because many of the homes in the village are over 100 years old and are a very important part of the tribe's history, it is important for the people of the Santo Domingo Pueblo to retain their traditions and culture as the reservation undergoes renovation.

The objectives we have established revolve around improving the current planning activities related to the housing crisis in the Santo Domingo Pueblo. We organized housing data in Geographic Information System (GIS) maps to support strategic planning and provide a database for future Santo Domingo planning analysis. We created a physical 3D model of the historic Village to use in presentations to the community. In addition, the 3D model will also serve as a tool for the SDTHA to help plan the future rehabilitation of Santo Domingo. Finally, we generated a five-year housing rehabilitation plan using selection criteria based on the collected GIS data. This plan will propose to the SDTHA the buildings our team believes should be rehabilitated first based on our research. Our project will help the Santo Domingo Pueblo develop their Community Master Plan which aims to preserve the traditional houses within the Village.

Our first task was to digitize all of the already collected data and organize it to make it easily accessible. Each survey was scanned and saved as a PDF file. The file name contains the unique number to the house, the subdivision, the family name, whether or not it is abandoned, and whether or not the family refused to complete the survey. We further organized data from the surveys using ArcGIS software. We created several color coded maps that visualize particular aspects of the survey over an aerial view of the historic village of Santo Domingo. The Santo Domingo Housing Authority and Atkin Olshin Schade Architects (AOS) will be able use these maps to target specific buildings with particular conditions they want to address in rehabilitation. Using the collected data and maps, we created a presentation for the SDHA to use when meeting with tribal council to gain support for future projects. This presentation contains infographics that illustrate the major trends within the village and demonstrate why rehabilitation projects could beneficial to the village.

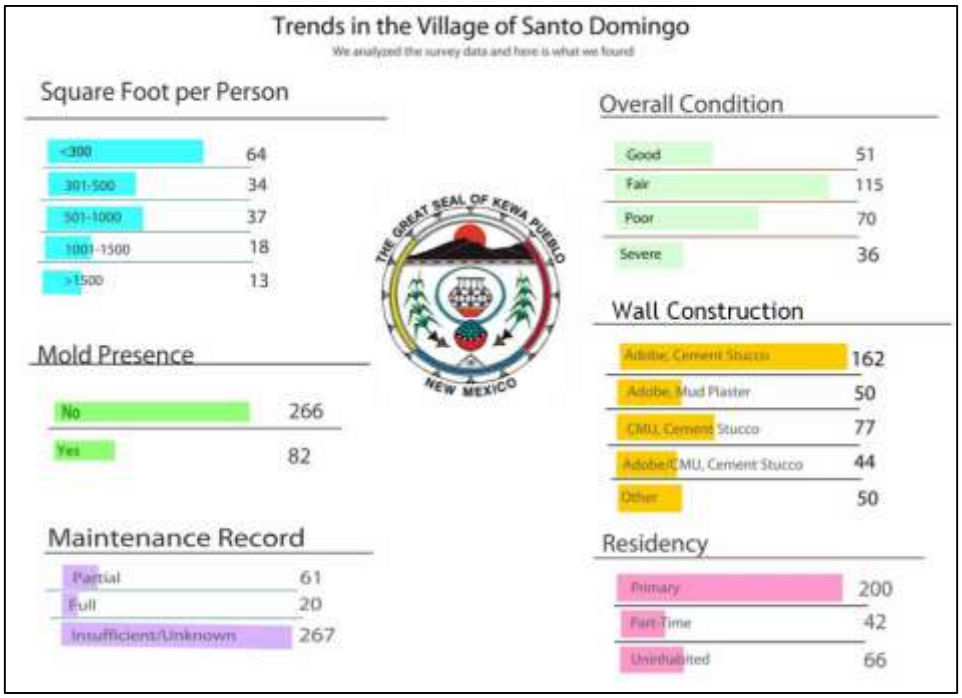

Figure 1: Housing Trends Infographic

To further help the SDTHA, the GIS layers were uploaded online. A web application was created using the new online map. The goal of the application is to make it easier for the villagers of Santo Domingo to complete the form required to request that their house be rehabilitated. The web application lists the relevant collected structural data for each building that has been surveyed in the village. The villagers will be able to click on their housing unit and have all of the information show up for them to use.

The SDTHA already had a physical model of the terrain of the Historic Village, so we modelled all of the buildings of the village and then 3D printed as many sections as we could to place on the terrain. Figure 2 shows the part of the Historic Village that we were able to 3D print. The completed 3D model of the entire village will serve as a visual tool for the SDTHA to plan future rehabilitation projects for Santo Domingo. A guide on how to split the models into smaller pieces was written in case some of the unprinted models ever needed to be divided for easier printing.

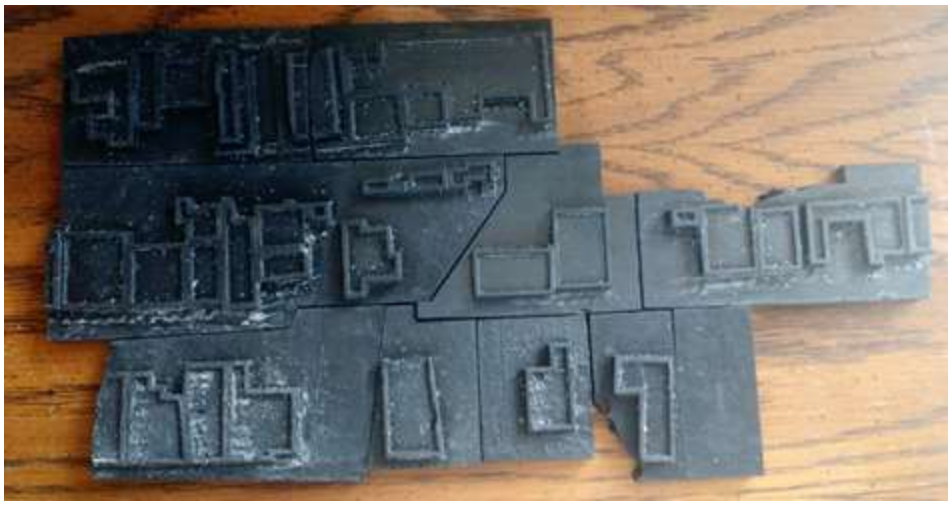

Figure 2: Successful Prints of the Village

Because of the issues inherent in using the Formlabs 3D printer, we decided to experiment with two other printing methods to test if they were better options. We tested the MakerBot 3D printer from the Santa Fe Indian School as well as a 3D printing ordering service called makexyz. In case the the Formlabs printer continues to be used, we created a guide covering removing a print from the Formlabs printer, setting up to the next print, proper steps for curing the print, and various issues we encountered while using the printer and how we solved them.

The final contribution that we made to our sponsor was a set of tools to help in future rehabilitation plans. We revised the survey created by AOS, making it more thorough and objective; created a visual assessment guide in order to standardize survey results; developed a point system to rank the buildings, an algorithm to weight the point system, and cost estimates for the surveyed buildings to use when creating potential rehabilitation plans.

We also created a few example five year plans in order to demonstrate the system we created. One example took into account all buildings with both parts A and B of the building survey completed and another only used data collected from part A. The final example plan was created to showcase the influence of the weighting system by weighing the population density by a factor of 2.

At the conclusion of our presentation, we also provided of list of recommendations for how we think all involved organizations should proceed with the rehabilitation of the Santo Domingo Pueblo. Using the point system we created, we were able to demonstrate multiple instances of potential 5 year rehabilitation plans for the Village. We created the different scenarios by weighting criteria within the point system differently each time to illustrate how the rehabilitation plan could change based on which criteria could be considered most important. Also, when analyzing the various 3D printing options, we found that the MakerBot produced the cheapest print, but also resulted in less precision and poorer structural stability. We suggest that the SDTHA use a printing service like makexyz in the future because while it might cost more than the Formlabs printer per print, it removes the time commitment needed to create the print in person and hassle with dealing with failed prints. We recommend the SDTHA and the Santo Domingo Tribal Planning Department choose one of the scenarios we demonstrated or, we recommend they reweigh the point system and choose houses to be rehabilitated in the next 5

years based on the criteria they deem most important. Once the SDTHA chooses how they want to proceed with the rehabilitation of Santo Domingo, they will have to propose their ideas to tribal members of Santo Domingo for approval. So, we recommend that the SDTHA uses the second presentation that we have made as a basis for proposing future planning ideas to the tribal members of Santo Domingo. Ultimately, we have left tools in place that we believe will forge the future rehabilitation of the Santo Domingo Pueblo.

Authorship

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Santo Domingo Land Use	Burke	Kollitz
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Creating Visualizations of the Survey Data	Kelly	Kollitz
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1. Introduction

Our project is meant to assist the Santo Domingo Pueblo plan the housing rehabilitation of existing homes and map out the construction of future housing developments that can better withstand damaging weather hazards. The Santo Domingo Pueblo is one of 566 federally recognized American Indian tribes and Alaskan Natives in the United States, which are all connected to the United States government by the United States Department of the Interior Bureau of Indian Affairs (BIA)[1]. The BIA offers many beneficial services to the native communities, but it has yet to solve the major issue of substandard housing in many tribal communities. In 2008, the U.S. Census Bureau reported that Native Americans are twice as likely to live in poverty compared to the non-native population, while the 2009 Annual Homeless Assessment Report demonstrated that American Indians make up eight percent of the country's homeless population despite comprising only one percent of the United States general population[2].

The Santo Domingo Pueblo is a culturally rich tribe with strong ties to tradition. Unlike many Indian tribes, the Santo Domingo Pueblo was not forced to relocate by European settlers or later by the United States government[3]. The national census reported that 2,456 people live in Santo Domingo as of 2010 with a majority of their children speaking the native Keresan, more than other tribes in the area[4]. The Pueblo has the largest reservation of all of the Keresan people and compared to other tribes that have forfeited land and lost important traditions, they are considered a great protector of Indian life and ways[5]. It is important for the people of the Santo Domingo Pueblo to retain their traditions and culture as the reservation undergoes renovation.

While culturally rich, the tribe has faced several economic and environmental challenges in recent history. Since more than 80% of the income from families in Santo Domingo come from sources including arts, crafts, and cultural product sales, the local economy can be considered unstable at times[6]. Upwards of 25% of tribal members live below the national poverty level[7], with an average per capita income of $6,038 in the 2000 census[8]. The occasional natural disaster presents a danger to the tribe as well. Since the tribe is very dependent on agriculture, a natural hazard impacting the crop output would also severely impact the health of the tribal members and the economy of the pueblo. For example, a hail storm in 2010 destroyed 80% of the tribe's crops and damaged 90% of the homes within the village. Because many of the homes in the village are over 100 years old and are a very important part of the tribe's history[9], The Santo Domingo Pueblo needs a planning strategy for rehabilitating existing houses in disrepair as well as developing new areas within the village that account for future issues, such as hail or flooding.

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[1] Bureau of Indian Affairs
[2] Committee on Banking, Housing, and Urban Affairs 2012. (Pg. 1)
[3] *Santo Domingo Cultural District* | *Exploring Our Town* 2015.
[4] U.S. Census Bureau 2010.
[5] Scully 1989 p. 175
[6] Loy, Alice 2014.
[7] *Santo Domingo Cultural District* | *Exploring Our Town* 2015.
[8] Loy, Alice 2014.
[9] Barber 2011

Some pueblos have already taken steps to achieve similar planning goals. Ohkay Owingeh, another Pueblo tribe, completed a comprehensive preservation plan that has prompted many other tribal communities to meet with the project team responsible for the turnaround and learn from their successes. The preservation plan resolved the poor housing quality in the area by carefully combining aspects of cultural traditions and contemporary life to rehabilitate twenty-nine homes, most of which were uninhabitable at the time[10]. The plan emphasized community engagement in order to involve tribal members in project activities that would directly affect their life. This project achieved a balance between traditional building elements and contemporary amenities while increasing employment within the Pueblo through preservation technology and construction method training[11]. The success of this tribal preservation has served as a model in recent years for projects that focus on heritage, natural materials, and engagement.

The Santo Domingo Pueblo and its partners have also been actively taking steps to initiate redevelopment similar to Ohkay Owingeh. In May of 2005, the Santo Domingo Tribal Planning Department was formed to develop a Community Master Plan that would integrate the historical and cultural aspects of the pueblo with its tribal mission to establish planning goals for the future[12]. The funding to initiate this framework came from the National Endowment for the Arts “Our Town Grant” in July of 2012, when the Santo Domingo Planning Department was awarded $100,000 to form a Cultural District Plan[13]. Although the Santo Domingo Pueblo has made progress in the design stages of these projects, future planning is needed to aid the success of the Cultural District Plan.

Several historic homes in Santo Domingo are in need of repair due to age and deterioration. The Santo Domingo Pueblo needs a plan to preserve the cultural significance of the tribe, while improving the structural quality of their historic buildings. The goal of this project is to assist the Santo Domingo Tribal Housing Authority (SDTHA) and Santo Domingo Tribal Planning Department to develop planning tools that will help create and maintain a long term plan for housing rehabilitation. The objectives we have established revolve around the improvement upon the current planning activities related to the housing crisis in the Santo Domingo Pueblo. We aimed to organize the existing housing data, make progress in creating a physical model of the historic Village and provide the Santo Domingo Pueblo with strategies to approach planning for future housing rehabilitation.

We have left a foundation of resources behind that the SDTHA, AOS Architects, and Santo Domingo Tribal Planning Department can build upon to create future planning projects. Ultimately, our project will help the Santo Domingo Pueblo develop their Community Master Plan which aims to create long-lasting housing for their new developments, while preserving the traditional houses within the Village that have stood for over 100 years.

[10] Ohkay Owingeh Model Balances Contemporary and Traditional Life
[11] Gonchar 2013
[12] *Santo Domingo Cultural District* | *Exploring Our Town* 2015
[13] National Endowment for the Arts 2015

2. Background

Modern Pueblo natives are descendants of the prehistoric Anasazi Indians[14]. These aborigines migrated from the north to the the Four Corners region,[15] where they settled before dispersing into groups to their current home villages in about 700-1000 A.D.[16]. This marked the birth of the Pueblo Nations and a new lifestyle centered around permanent homes and agriculture. Figure 3 displays the location of the 19 Pueblos as well as other Indian Reservations in New Mexico.

Figure 3: Map of 19 Pueblos[17]

The Pueblo Nations, while evolving from their prehistoric ancestors, have undergone changes in languages, customs, and religious practices between each tribal community. Pueblo oral history shows that by mid-14th century, most of the Pueblo people were located either in the Colorado Basin, The Acoma-Zuni-Hopi Crescent, or the Rio Grande Basin[18]. Conflict began to develop for the the Pueblo Indians in 1540 when Spaniards arrived on an expedition led by Francisco Vasquez de Coronado, settled in New Mexico, and asked for food and clothing from the tribal communities. The Spaniards introduced Christianity to the area and managed to convert over 60,000 Pueblo Indians, while also spreading European diseases that killed as many as 80% of the members in some villages. After revolutions against the Spaniards in 1680

[14] Bonk and Carson 2000.
[15] Sando 1992.
[16] Bonk and Carson 2000.
[17] https://edu497puebloindians.files.wordpress.com/2015/02/pueblo-map.gif
[18] Visit to Pueblo Cultural Center.

and 1736, the power of the Catholic Church diminished and the Pueblos restored their freedom[19].

In the 1950s Pueblo Culture evolved with increased populations, improvement in health, revival of native religious practices, and more comprehensive legal rights. Despite constantly evolving, pueblo culture has always had ancient roots, dating back 600 years to the territory of the Rio Grande valley which comprised of 17 villages with a total of about 24,000 tribal members[20]. Although changes did occur during the influential period of Spaniards and Anglos, the Pueblo Nations displayed retention of prehistoric culture with similar crafts, buildings, and religious ceremonies.

2.1 The Santo Domingo Pueblo

The Santo Domingo Pueblo was established when their 15th century ancestors migrated from what is believed to be the Frijoles Canyon region in Los Alamos, NM,to the current location centralized between Santa Fe and Albuquerque[21]. The Keresan-speaking people settled into several distinct villages, the Cochiti, San Felipe, Acoma, Laguna , Santa Ana, Zia, and Santo Domingo Pueblos[22].

2.1.1 Santo Domingo History

The origin of the name Santo Domingo Pueblo is derived from St. Dominic in the 13th century from the Spanish preacher who founded the Dominican order in the area[23]. The creation of the Santo Domingo Pueblo as a permanent settlement stemmed from the arrival of Spanish explorers and colonizers in the early 17th century. The community members initially welcomed the arrival of the Spanish as it became easier to combat raiders of other indian tribes. In return, the Spanish established Santo Domingo as a headquarters in the colonial mission system. During the alliance with the Spanish, the Spanish People oppressed the members of the Pueblo with strict governmental and religious policies. The Spanish attempted to impose Catholicism on the strongly religious and traditional tribal members. The Spanish tortured those who resisted the religious change and even sold some of them into slavery. Eventually, Santo Domingo became one of the centers of the tribal members' revolt against the Spanish around 1680[24]. The violent interactions between the Spanish and the Pueblo members came to a halt around the start of the 18th century, allowing Santo Domingo to grow into the community that it is today[25].

2.1.2 Santo Domingo Culture and Traditions

Nature and agriculture have always been the focal points of the tradition, religion, and culture of Santo Domingo. The community members believe that people are meant to have a sacred connection with nature and with the cosmos. Many of their rituals and ceremonies serve

[19] Acatos 1990.
[20] Ibid
[21] Morgan and Swentzell. 2014 p. 260
[22] Griffin-Pierce, T. 2000 p. 39
[23] Constable 2010. Santo Domingo Returns to its Traditional Name. *The Santa Fe New Mexican*.
[24] Mooney, James. 2015. *Pueblo Indians* (Vol. 12). Robert Appleton Company 1911 [cited February 9 2015]. Available from http://www.newadvent.org/cathen/12554b.htm.
[25] *Pueblo of Santo Domingo--Route 66: A Discover Our Shared Heritage Travel Itinerary*. 2015. Available from http://www.nps.gov/nr/travel/route66/pueblo_of_santo_domingo_kewa_pueblo.html.

the purpose of bringing positive weather patterns to the area. For example, the key religious figures, Kachinas, are entities that tie the bond between the cosmic and worldly realms and are believed to bring rain from the cosmos. They also have many rituals and dances that bring rain and provide bountiful crops and produce. For example, they use a hunting dance in February and The Corn Dance in August to mark the poles of the agricultural year[26]. Ultimately, tribal members find very sacred meaning in the bond with nature and our project should do nothing to interfere with that bond.

The Santo Domingo Pueblo has a conservative and traditional culture in the sense that they seek to preserve their private ancient ideals. Living in their tribal homeland for thousands of years has given them a strong sense of community and history. Over 80% of the children in the village speak the native language, Keresan[27].The combination of being in their native home and having such ancient pueblo buildings and traditions has made the Santo Domingo Pueblo community tightly linked to its heritage.

Recently, the tribe has decided to rename themselves as the Kewa Pueblo which is the name they have always called themselves within the tribe. Since the change, the train stop for their reservation has been changed from the Santo Domingo Station to the Kewa Station and many small business owners in the village have also renamed their stores, embracing the change. The name change has been recognized at a federal level but the tribe is still in a transitional period switching from Santo Domingo Pueblo to Kewa Pueblo. The change was made without an official announcement, and many of the tribal members still do not know about the change. The tribe has been relying on "word of mouth" to inform its members[28]. The seals for both the Kewa and Santo Domingo Pueblo are shown below in the Figure 4 and Figure 5.

Figure 4: Kewa Pueblo Seal[29]

[26] *Pueblo of Santo Domingo--Route 66: A Discover Our Shared Heritage Travel Itinerary*. 2015. Available from http://www.nps.gov/nr/travel/route66/pueblo_of_santo_domingo_kewa_pueblo.h

[27] *Santo Domingo Cultural District | Exploring Our Town* 2015

[28] Constable, Anne. 2010. Santo Domingo Returns to its Traditional Name. *The Santa Fe New Mexican*.

[29] *Kewa-Pueblo.jpg*. 2015. Available from http://cdn2.nativeamericanencyclopedia.com/wp-content/uploads/2012/11/Kewa-Pueblo.jpg.

Figure 5: Santo Domingo Pueblo Seal[30]

. The move back to their traditional name further implies the need for sensitivity when proposing to integrate new ideas that could potentially interfere with their core values.

2.1.3 Santo Domingo Climate Challenges

Climate challenges have existed throughout the history of the Santo Domingo Pueblo. Flash flooding occurrences have proven to be some of the biggest risks that affect the Pueblos. New Mexico has a history of flash floods caused mainly by the summer monsoon season. Although a flash flood is a very brief occurrence, it can cause significant damage if there is a lack of preparation. The low frequency of these events, as well as the rapid accumulation of rainfall, make them difficult to manage. Flash flooding is a year round problem as it can have many causes such as heavy rainfall, melting of heavy snow, and erosion. In the late 1600's and in 1886, flooding from the Rio Grande forced the Santo Domingo Pueblo to rebuild their village due to the destruction the river caused[31].

Severe weather is a problem year-round in New Mexico, even though it may seem it is a primarily hot and dry climate. The pueblo region is susceptible to severe winter weather, high winds, and hail in addition to all the risks associated with the dry season and monsoon season. Although these cold weather risk are not as often of a problem for the Pueblos, they still can have disastrous effects when they do happen. The largest winter storm in the history of the state came April 1, 1988 and dropped nearly two feet of snow which also led to flash flooding upon melting[32]. Climate risks have always plagued the pueblos and there must be future planning to mitigate these risks to protect the pueblos as they stand today. These climate issues are often difficult to plan for due to unpredictable weather patterns. The flood and hail risk needs to be mitigated in order to prevent damage to the Pueblo buildings in the future.

2.1.4 Santo Domingo Economy

Today, a large population of the people within the village are craftsmen, carrying on an artisan based economy that started in the 1950's with the introduction of Route 66[33]. Unlike some tribes in the area, the Santo Domingo Pueblo is a non-gaming tribe which means they do not have a casino to utilize as a source of income[34]. The tribe has more than 25% of its

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[30] *Santo Domingo Pueblo*. 2015. Available from http://www.indianpueblo.org/19pueblos/santodomingo.html.
[31] *Pueblo of Santo Domingo--Route 66: A Discover Our Shared Heritage Travel Itinerary*. 2015. Available from http://www.nps.gov/nr/travel/route66/pueblo_of_santo_domingo_kewa_pueblo.ht
[32] *Pueblo of Santo Domingo--Route 66: A Discover Our Shared Heritage Travel Itinerary*. 2015. Available from http://www.nps.gov/nr/travel/route66/pueblo_of_santo_domingo_kewa_pueblo.ht
[33] *Santo Domingo Cultural District | Exploring Our Town* 2015
[34] Martinez 2011

members living below the poverty line and has a similar unemployment rate[35]. This led to parts of the village needing renovation and rejuvenation because of a lack of income.

2.1.5 Santo Domingo Land Use

The Santo Domingo Pueblo has two separate main sites. The historic Village is the main residential area and serves as the location for many of the tribe's traditional activities; the Domingo area is located about two miles east from the Village and contains very limited present development [36]. Figure 6, which is shown below, displays the relative location of the historic Village and the Domingo area.

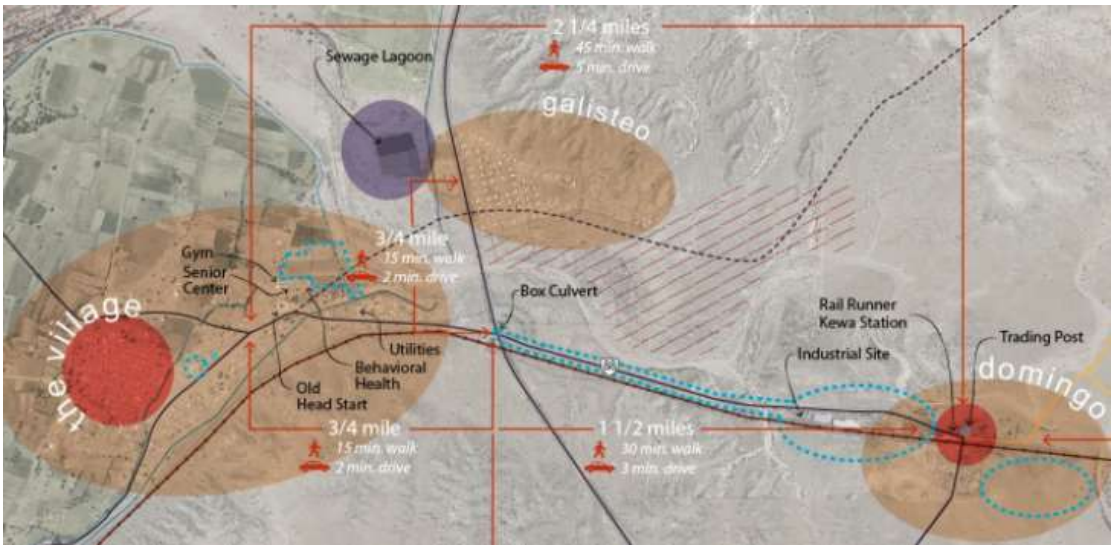

Figure 6: Map of Village and Domingo[37]

At one point, Domingo was a mercantile center with a train depot, but over the years many of the buildings deteriorated and have since been abandoned. A relatively recent project in the Domingo area was the restoration of the Kewa Depot that has served as one of the central stops between Albuquerque and Santa Fe for the New Mexico Rail Runner since 2010[38]. The historic trading post is also located in this area, and has been progressively restored since the opening of the Kewa Depot, so that it can serve as a retail center for pueblo arts and crafts[39]. Unfortunately, there is no pedestrian or transit route from Domingo to the historic Village, which causes unsafe conditions for those entering and exiting the Village by foot. The land in Domingo currently lacks development and a connection with the historic Village, but Pueblo officials are planning the development of 41 housing units on an 8.5 acre plot of land, along with trails and infrastructure connecting the two sites on the Reservation[40].

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[35] *Santo Domingo Cultural District | Exploring Our Town* 2015
[36] *Santo Domingo Cultural District | Exploring Our Town* 2015
[37] Morgan and Swentzell 2014 p. 260
[38] SW Case Studies. Sustainable Native Communities.
[39] Garcia 2014
[40] Kunkel personal communication 2015

The oldest part of Santo Domingo is called the Village, but it also includes new housing developments that have been added over time. The central area of the Village consists of plazas that account for a significant portion of the local tourism. There over 500 traditional homes that are clustered in blocks, sharing common roofs and walls, that line east-to-west parallel streets[41]. This conservative style uses an ordered layout, which is different from modern pueblos that usually consist of houses built on the outskirts of villages in rural areas. A new housing development is being planned outside of the Village area. Off of Route 22 and just outside of the main historic Village boundary there is a school, the Head Start Program, health services, the Kewa Safety Complex, and a gas station[42]. Agricultural land surrounds these developments and creates a defined boundary between the separate sections of the reservation. Future planning in the Santo Domingo Pueblo aims to tackle the development issues that it is facing while still preserving this land pattern.

2.1.6 Santo Domingo Architecture

Following the flood in 1886 that demolished a significant portion of the historic Village, a majority of the buildings were rebuilt using traditional adobe construction for that time. The buildings have adobe and plaster footings and exterior walls. The floors and roofs are earthen, and the built up roofs contain vigas, which are large round wood timbers for roof framing[43]. The housing units are clustered in blocks, sharing common walls and roofs, separated by parapets.

2.2 Adobe Building Life Cycles

The original benefit of using adobe as a structural material was mostly convenience. Clay, gravel, sand, and water were common resources, and the insulating nature of the adobe bricks helped keep houses warm in winter and cool in summer. But because adobe buildings are old and made of earth, they degrade relatively easily and need to be regularly maintained to keep them properly preserved. In order to best preserve the building, repairs should be made with materials as similar to the original building as can be obtained.

2.2.1 Adobe Construction

Native Americans had built their homes out of earth and stone for centuries, but the technique of crafting the earth into adobe bricks, first mixing the mud with straw for strength was introduced by the Spaniards and is now referred to as the mold method. Traditional adobe is a type of sun dried brick made from a mixture of sand, clay, water, and straw or grass. The particular ratio of components varies slightly by region, depending on the local earth composition. The bricks are stacked to form walls surfaced with a mud plaster. The roof is historically made from a layer of wooden slats or twigs (called latias) placed laterally over support logs (called vigas) and then covered with compacted adobe earth[44]. Traditional adobe buildings typically have flat roofs, upper floors accessible only by ladder, and few windows. The windows that were present were often barred with a few pieces of wood, and ground floor doors would be open entryways covered by cloth if covered at all. Adobe has been the traditional building style for the Pueblo since they arrived in the the Southwest.

[41] United States Department of Housing and Development 2013 p. 14
[42] Kunkel. Case Study: Santo Domingo Pueblo
[43] United States Department of Housing and Development 2013 p. 14-15
[44] Tiller, De Teel, and Look 1978

2.2.2 Deterioration of Adobe Buildings

Common sources of deterioration include water, wind, and material incompatibilities. Since traditional adobe structures are made from earth, rain and groundwater can do significant damage. Roofs and walls are easily eroded by rainfall, and when they dry after a storm, they can develop cracks and pitted surfaces. The adobe bricks themselves can also be damaged by repeated soaking and drying, often losing integrity and crumbling. In addition, if the foundation of the building is not properly drained, any standing water that gathers at the base of the structure will cause coving (a hollow space underneath the bottom of a wall). In extreme cases, the adobe will be saturated by water and will start to behave more like a liquid than a solid. Wind erosion is less prevalent than water damage, but it is possible for sand lifted by the wind to furrow the walls, and can be differentiated from water erosion by its visibility on the upper part of the walls and near the corners of the roof. Another common source of damage arises from repair attempts. Some techniques used to maintain and preserve adobe buildings in the past are no longer recommended because of the incompatibility of the materials. For example, some of the weaker materials, such as the mud mortar, were replaced by stronger ones, such as cement mortar. This may seem like an improvement at first, but the adobe ends up falling apart under the pressure caused by the different rates of expansion of the two materials[45].

Figure 7: Evidence of Coving in Adobe Building[46]

2.2.3 Deterioration of Adobe Buildings in Santo Domingo

Many of the buildings in the historic Village of Santo Domingo are over 100 years old and have lacked proper care to maintain sufficient condition. Because community funding to preserve the architecture has not been available, inexperienced homeowners have taken it upon themselves to attempt repairs themselves. Improper construction methods such as the use of cement plaster instead of mud plaster over adobe and the use of asphalt roof paper have caused rapid deterioration and the confinement of moisture[47]. The moisture has accelerated the growth of mold, which is one of the many problems, along with the collapse of walls and roofs. The deterioration over the years has occurred due to the lack of maintenance and has led to

[45] Tiller, De Teel, and Look 1978
[46] http://www.nps.gov/tps/how-to-preserve/briefs/5-adobe-buildings.htm
[47] United States Department of Housing and Development 2013 p. 14-15

about 60% of the homes evaluated as in poor condition[48]. The deterioration of these adobe buildings require effective rehabilitation to prevent the need for demolition and reconstruction.

2.2.4 Repair and Maintenance of Adobe Buildings

The complete rehabilitation of historic adobe buildings to ensure a structurally sound building involves many aspects of repair. These include repairing or replacing the adobe brick, mortar, surface coatings, wood members, and roof. The most important detail to follow in the restoration of adobe buildings is to avoid material incompatibilities.

When adobe brick must be replaced, the bricks must be made of unstabilized adobe with no chemical additives[49]. The same standard applies when replacing the mortar, as adobe mud mortar should not be substituted by lime or portland cement mortar. When replacing the surface coating of the exterior adobe walls, the type of material originally used plays a greater role in what steps must be taken for proper repair. The most highly recommended surface coating, mud plaster, should be scraped off and replaced with a similar material, while deteriorated lime plaster and portland cement stucco, require more care since there is most likely detrimental deterioration below the surface[50]. This case requires the construction of a moisture barrier by furring out the walls with lathing and plastering over them.

The final component of an adobe structure that may need repair is the roof. A roof may undergo repair either by the restoration of an existing roof, or the construction of a new one. During the restoration of an existing roof, a fresh layer of adobe mud is placed. This addition requires temporary support of the roof due to the excessive loads from wet mud compared to the cured material[51]. Similar precaution must be taken in the construction of a new roof, as it must be lighter than the previous one to prevent the walls from bulging[52]. These repairs involve complex techniques and therefore must be completed by experienced professionals to ensure successful rehabilitation.

2.2.5 Repair and Maintenance of Adobe Buildings in Santo Domingo

Buildings that were recently rehabilitated in the Santo Domingo Pueblo required cautious architectural planning to properly restore the roof beams and adobe walls. This was done to preserve both the wall systems and historic appearance of the buildings. The plans for future rehabilitation include wall repairs using mud or stucco, improved insulation, water saving plumbing fixtures, and the installation of energy star components such as windows, doors, heating, and appliances[53].

Architectural preservation is one of the most important goals of the current plan for the buildings in Santo Domingo. The goal of rehabilitating the interiors is to compliment the traditional construction elements that are capable of coexisting with modern and sustainable features. The point of this approach is to strive to enhance present architecture in the historic Village so that it is safe, affordable, and environmentally relevant while remaining culturally and

[48] ibid
[49] Clifton 1977 p. 15
[50] Technical Preservation Services
[51] Technical Preservation Services
[52] Clifton 1977 p. 16
[53] United States Department of Housing and Development 2013 p. 19

spiritually appropriate rather than attempting to restore the architecture to a particular time period of Santo Domingo[54].

2.3 Housing Rehabilitation in Santo Domingo and Other Communities

The need to rehabilitate buildings and communities on Indian Reservations stems from the poor housing quality that they face.

2.3.1 Housing Quality Challenges in Native Communities

Housing issues in the United States arise from either inadequate space and quality or lack of affordability. The measurement of housing space refers to the capacity of people per unit; more than one person per bedroom is considered overcrowded. Quality can be determined by the absence of satisfactory plumbing and kitchen amenities. Housing units are deemed unaffordable when the ratio of housing cost to household income is greater than 30%[55]. In comparison to contemporary United States homes, tribal housing in Indian Country had greater problems with these defined issues. According to the 2000 census, 18.6% of Native American housing units were overcrowded and in 10.2% of the units acceptable plumbing and kitchen facilities were absent. These statistics were comparable with nationwide housing levels in the 1940s and 1960s even though housing has substantially improved since those times[56]. Special interest groups have attempted to resist this decay of housing standards, such as the Office of Native American Programs. Also,The Office of Native American Programs established the 1996 Native American Housing Assistance and Self Determination Act, which guarantees federal housing assistance for indigenous tribes that complies with tribal sovereignty[57]. The provision of funding is a stepping stone in solving tribal housing issues but, it requires cooperation of all parties involved to create a successful housing program.

2.3.2 Housing Quality Challenges in Santo Domingo

The deficient housing quality epidemic is prevalent in the Santo Domingo Pueblo. Substandard housing and their characteristics, including poor design and construction, overcrowding, insufficient ventilation and use of wood-burning stoves, have been known to contribute to indoor air pollutants[58]. Mold and mildew formation has also been a problem in the Santo Domingo homes, forcing sixty six families to face health risks and evacuate their homes. Not only did the damaged home cause various health problems, but reconstruction costs were estimated to be up to $2 million[59]. Asthma and other respiratory illnesses are more common among Alaska Native and American Indian people compared to white and black ethnicities, which indicates the presence of underlying health effects to residents of these poorly built pueblo houses[60]. Due to the Native American Housing Assistance and Self Determination Act,

[54] United States Department of Housing and Development 2013 p. 20
[55] Bland, et. al. 2004 p. 197
[56] 2000. Bureau of the Census. Census 2000, summary file 1: Census of population and housing. Washington, D.C.: U.S. Department of Commerce, Economics and Statistics Administration.
[57] Native American Assistance and Self Determination Act of 1966
[58] Seltenrich
[59] Martinez 2011
[60] Seltenrich

state and local government building codes do not apply on tribal lands.[61] Therefore, tribal communities do not require sustainable practices to be implemented in building design and construction that would otherwise promote improved indoor air quality and a healthier population.

A pre-assessment for one of the housing projects in 2010 showed that 60% of the homes in the historic Village do not meet Housing Quality Standards, and about 20% of them are vacant due to excessive deterioration[62]. The homes display substantial damage such as collapsed roofs and walls, presence of mold, and dysfunctional plumbing, weatherization, and bathrooms. Some of these homes even lack the presence of modern doors, windows, electrical systems, and energy efficient appliances. Damage is propagated for a variety of reasons ranging from old age to the inability for elderly and disabled homeowners to properly maintain the structural and architectural integrity of the homes[63]. The housing quality of the Santo Domingo Pueblo poses health and safety risks, and is causing tribal members to move out of the historic Village in order to seek better housing.

2.3.3 Historical Preservation

The National Historic Preservation Act of 1966 set the standards for guiding future development and preservation in order to reflect on the nation's historical heritage. It states, "the historical and cultural foundations of the Nation should be preserved as a living part of our community life and development in order to give a sense of orientation to the American people." and "The preservation of this irreplaceable heritage is in the public interest so that its vital legacy of cultural, educational, aesthetic, inspirational, economic, and energy benefits will be maintained and enriched for future generations of Americans"[64]. These statements represent the varied motives for historical preservation, whether it comes from the desire to have permanence and community, or to incorporate America's heritage into the everyday lives of American citizens.

The National Park Service studied the preservation needs of Indian Tribes and discovered that many of them strongly believed in preserving historic properties, languages, and traditions, while continuing to live a contemporary life[65]. Other findings from the study suggested that participation in the national historic preservation program lacked tribal participation due to inappropriate recognition of tribal sovereignty and insufficient respect for tribal values. In addition, since publicly funded activities directly led to publicly available information, the preservation program met with disapproval from those who felt these policies did not appeal to tribal cultural values. In some cases, this public access conflicted with the restricted cultural and religious information held by the tribes. Because of this, the standard approach used in the traditional American society needed to be modified in order to be successful. The Tribal Historic Preservation Program was established to work and cooperate with the Grants Division in the Cultural Resources Department of the National Park Service.[66] Working alongside tribal officials,

[61] Native American Assistance and Self Determination Act of 19
[62] United States Department of Housing and Development 2015 p. 14
[63] ibid
[64] National Historic Preservation Act of 1966
[65] Banks and Parker 1990 p. 167
[66] *Tribal Historic Preservation Grants*. National Park Service.

the program constructs preservation activities that utilize the knowledge and participation of the Indian Tribes.

2.3.4 Historical Preservation in Santo Domingo

The Historic Village of the Santo Domingo Pueblo has been on the National Register Historic District since 1973[67]. The New Mexico Historic Preservation District serves to identify the unique character of any historic district, such as the Village, to better protect and preserve it. According to their goals and objectives of 2012 to 2016, the office focuses on improving partnerships with federal, state, and tribal governments to create collaborative effort in protecting and preserving cultural resources. They also strive to promote community outreach to the state legislature to promote their involvement in preservation and benefits of their programs[68]. The active participation in historic preservation programs by the Santo Domingo Pueblo, shows that their planning strategies are less motivated by the physical buildings, and more about the culture being preserved as they move forward.

2.3.5 Owe'neh Bupingeh Preservation Project

One of the Indian Pueblos, Ohkay Owingeh, recently sought out a housing rehabilitation plan to solve the tribal community's housing quality problem. The preservation and renovation plan involved resolving the poor housing quality in the area. This was completed by carefully combining and applying aspects of cultural traditions and contemporary life to rehabilitate sixty homes, most of which were uninhabitable at the time. Since complete restoration did not seem feasible following the analysis of 400 historic photos, the Standards for the Treatment of Historic Places had to be reinterpreted in a way that prioritized the local needs of preserving culture as opposed to just building better homes. Therefore the preservation plan was more a series of practical housing improvements that respected cultural values[69].

The plan emphasized community engagement in order to involve most tribal members. A $7,500 grant from the New Mexico Historic Preservation Fund provided tribal youth with the opportunity to become educated in the project activities and allowed them to document and research the existing buildings to develop a preservation program that would eventually earn the community more than $8 million in additional funds. Tribal elders also played an important role in the process, contributing oral histories, providing recollections of buildings that were no longer present, and elaborating on traditional values. Other community members participated in the project by attending a series of planning meetings designed to provide feedback to the designers by initiating discussions with the Tribal Council and creating a Cultural Advisory Team[70]. An overview of this project is shown in Figure 8, showing the project costs and which initiatives were taken to complete the project.

The project led to a successful balance between traditional building elements and contemporary amenities, while increasing employment within the Pueblo through preservation

[67] United States Department of Housing and Development 2013 p. 14

[68] Preserving the Enchantment: Sustaining New Mexico's Cultural Heritage 2012-2016. New Mexico Historic Preservation District.

[69] Ohkay Owingeh. Sustainable Native Communities Collaborative.

[70] Ohkay Owingeh Model Balances Contemporary and Traditional Life. edited by Advisory Council on Historic Preservation.

technology training. It also serves as a model rehabilitation project for other Pueblos to have a basis for their planning goals and activities.

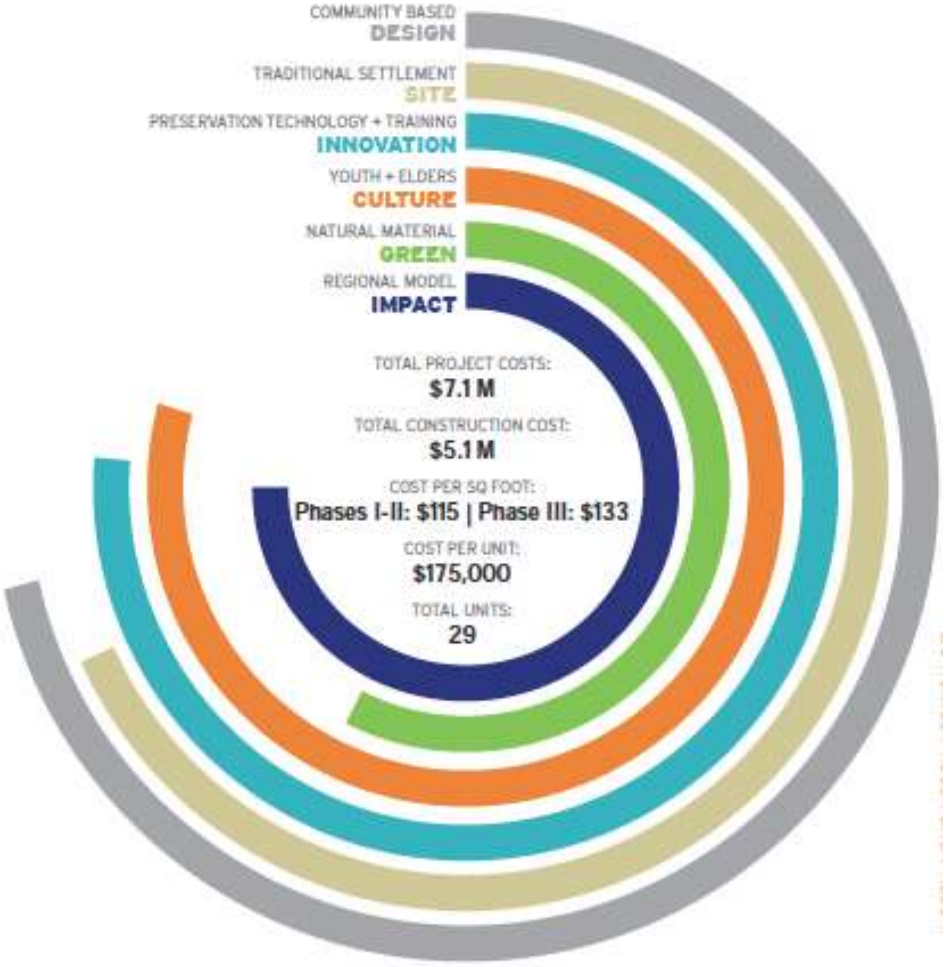

Figure 8: Project Details for Ohkay Owingeh Tribal Preservation[71]

2.4 Planning Strategies for Housing Rehabilitation

Small communities, such as rural areas and tribal lands, have different planning theories than urban and suburban areas. Although both groups require planning processes to cultivate good practices for the economy, public health, and environmental sustainability, small communities are often overlooked by federal assistance. Limited resources and attention must be offset by the effective use of planning strategies. To this end, several tribes have started to incorporate Geographic Information Systems (GIS), community participation, and comprehensive master planning programs into their communities. GIS technology is a software platform that allows users to view spatial, statistical, and quantitative data in specific geographic locations. The program is primarily used to analyze the connection between a building or landmarks location in space and the characteristics associated with it. Planners utilize these programs to combat the prevalent issue of unacceptable housing quality.

[71] Ohkay Owingeh. Sustainable Native Communities Collaborative.

2.4.1 Adopting Geospatial Technology

Community planners use GIS to guide future projects by identifying how the land use has changed over time and which areas of a community require focus on new construction and maintenance. In 1990, the Bureau of Indian Affairs founded the Geographic Data Service Center in Lakewood, Colorado[72]. This institution planned to introduce geospatial technology to the tribal people and train tribal officials so that they could implement the tool in their planning decisions. The Bureau of Indian Affairs currently has another program in place that is dedicated toward providing GIS software, training, and system support for management of natural resources on Indian lands. The Office of Trust Services Geospatial Support has aided in the initial setup of GIS implementation in tribal communities and hosts training and workshop sessions for tribal officials[73].

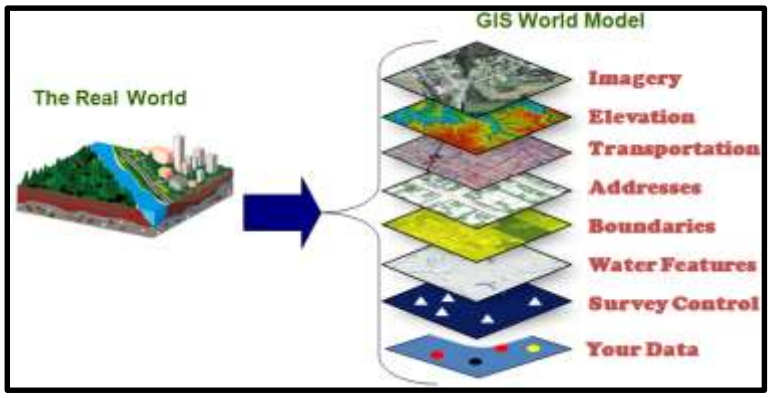

Figure 9: Example of GIS Layers Commonly Used[74]

The Pueblo of Zuni, located in New Mexico, developed a GIS Department with the help of the Office of Trust Services Geospatial Support by creating a database that helps support planning activities related to agriculture, archaeology, culture, restoration, water, and wildlife[75]. Similar to the Pueblo of Zuni, The Santo Domingo Pueblo has shown interest in the use of GIS for planning activities. The proposal to the Tribal Infrastructure Board for the Pueblo of Santo Domingo Community Master Plan identifies the need for more visionary planning to encourage practical development. This starts with mapping out the land to identify current land use patterns and documenting the data for future growth as well as historical preservation. The pueblo's officials have requested funds for GIS hardware and software to aid in creating this repository of land maps.[76] As The Office of Trust Services Geospatial Support continues to provide the necessary GIS equipment and training to tribal officials, planners will integrate traditional geospatial thinking with modern technology to enhance the planning process in tribal communities.

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[72] Craig, Harris, and Weiner 2002 (Pg.283)
[73] *Office of Trust Services Geospatial Support*. U.S. Department of the Interior: Indian Affairs 2015. Available from http://bia.gov/WhatWeDo/ServiceOverview/Geospatial/index.htm.
[74] "The Real World vs. GIS World Model."
[75] Lalio 2009
[76] Community Master Plan: Pueblo of Santo Domingo.

2.4.2 Participatory Planning

Decisions in planning the land use, environmental resources, and economic development of a community are carried out by a planning board, but in most cases, better results are produced when community participation is incorporated into the process. Participatory planning is based on the idea that the residents of the community are stakeholders in future planning, and with their devotion to the community, they will take action to contribute to their collective vision[77]. Development in Ohkay Owingeh is a great example of this, as the Owe'neh Bupingeh Preservation Plan was directed by tribal cultural values from all members. This project was a recipient of a prestigious planning award called the 2013 Housing and Urban Development Secretary's Opportunity and Empowerment Award, while the 1970 housing rehabilitation projects did not take public opinion into consideration and therefore caused residents to move out of the center of the village[78]. Since the community vision is intended to represent the best interest for the majority of the population, planning officials seek to involve the public throughout each step of the process.

The process of integrating public participation into community planning requires community engagement. Some ways to engage the community include conducting surveys, organizing school activities related to planning, and inviting the public to attend planning team meetings[79]. These activities should lead to developing a list of issues to address at community meetings and public hearings. When a method of reaching out to all members of the community is established, the planning team seeks to prepare a vision for the community by gaining insight from active citizens. This insight would come from a series of questions such as, "What makes our community what it is today?", and "What are our community's values with respect to the environment, economic growth, and lifestyle?" [80]. Effective community participation aims to gather opinions and ideas related to these issues from people with different views and backgrounds. This collaboration will help identify needs and solutions, setting priorities for action, and carrying out a plan[81].

The Santo Domingo Pueblo has expressed citizen participation in past events. The Community Heritage Walk was held to engage the community about the development that is being planned for the village and help the planners learn about the values of the tribal members. The event was successful due to the participants' reflective stories on the Pueblo's past. This sharing of history between generations informed planners of cultural appropriateness and place making in community planning. It also brought together all demographics from the tribe including youth, elders, and tribal leaders[82]. Events like the Community Heritage Walk allow the community to accomplish their goals of sustainable impact and a long term commitment to change.

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[77] Sanoff 2000 p. 12
[78] Sustainable Native Communities Collaborative.
[79] United States Environmental Protection Agency 1994 p. 10
[80] Ibid p. 13-14
[81] Ibid p. 15
[82] Kunkel, et. al. Project Summary: Santo Domingo Heritage Walk 2013

2.4.3 Comprehensive Planning

The guidance of a community's future lies in the Comprehensive Plan, which can also be referred to as a Master Plan, General Plan, of Municipal Development Plan. The key purpose of this plan is to direct the physical development of an area through policies related to land use and decision-making. Many Comprehensive Plans develop strategies for numerous elements including housing, transportation, utilities, community facilities, economic development, intergovernmental cooperation, land-use, implementation, and agricultural, natural, and cultural resources[83]. Communities encompass all of the previously mentioned strategies, like using GIS, community participation, historical preservation, and assessing the housing quality, to contribute to the adoption of a Comprehensive Plan. These plans are very flexible, but they should be consistent with all ongoing planning processes and should be developed for a ten to twenty year period in which it is constantly revised for unexpected changes.

2.4.4 Community Heritage Walk

On August 24, 2013, over 100 tribal members participated in the Santo Domingo Heritage Walk, which was organized by the SDTHA, the Santo Domingo Tribal Planning Department (SDPD), and Atkin Olshin Schade Architects. The two-mile walk served as a productive learning experience for both the tribal members and the designers, who seeked ways to connect the trail to the culture of Santo Domingo. The community engagement process was used to design a culturally-relevant arts based trail that was unique to all members of the community. Present at the walk were tribal leaders, planning officials, elders, and youth, all of whom helped generate ideas that would benefit the community's future and preserve its history.

[83] Cullingworth 2008 p. 126-136

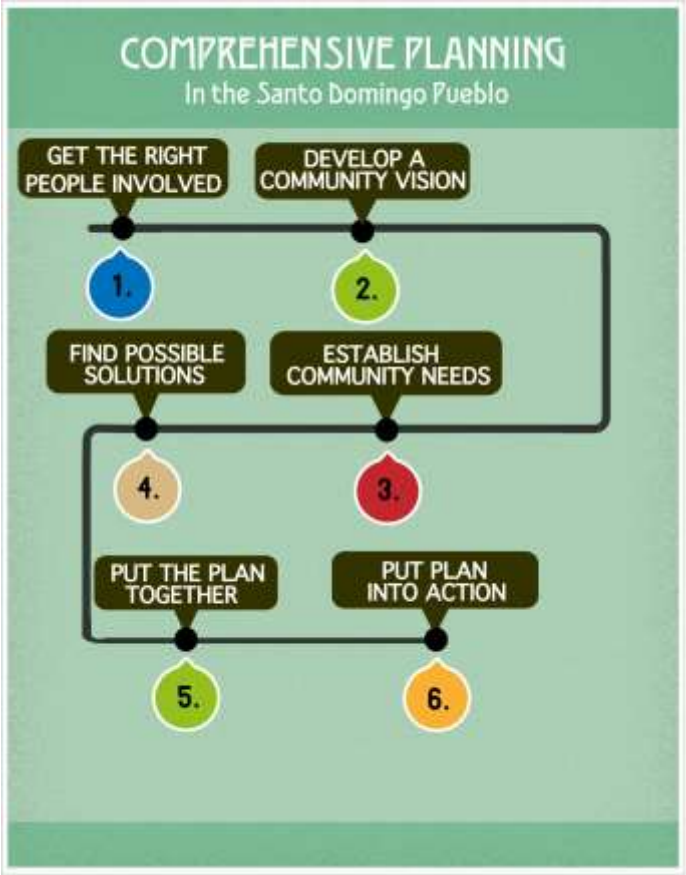


Figure 10: Comprehensive Planning Flowchart

Santo Domingo is currently in the process of adopting a Master Plan, since it will aid in the influx of development projects that are expected in the coming years. They hope to address economic growth, rehabilitation, and future housing developments.

2.5 Santo Domingo Community Master Plan

The Santo Domingo Pueblo is currently working on a community master plan to map out economic and cultural development for their tribe . The last community plan was drafted in 1964 by the state and only focused on economic development. The tribe applied for funding from the Tribal Infrastructure Board in April of 2013 for their Community Master Plan. They requested $100,000 to create their master plan while also committing $116,420 from their tribe to support a two year development process for the plan. Their objective is to complete the plan within 24 months of being awarded funding by the Tribal Infrastructure Board[84]. Key players in the development of the Master Plan are the Santo Domingo Tribal Planning Department, the Santo Domingo Tribal Housing Authority, the Tribe's Behavioral Services, and the Tribal leaders[85].

The current leaders of the tribe want to create a plan that will withstand leadership changes and will actively involve their community. The initial work for the master plan involves

[84] Community Master Plan: Pueblo of Santo Domingo.
[85] ibid

connecting the historic Village with the Domingo area to establish a single cultural district[86]. It will also include guidelines to improve the economic opportunities for Pueblo Members. The restored trading post and Rail Runner Depot are also key components to this Master Plan, since they encourage tourist programs. Additionally, the rehabilitation and construction projects that are in the planning stages will bring more job opportunities and sustainable re-development to the area[87]. To make sure the plan is being developed correctly, the tribe will evaluate progress in three month intervals and establish benchmarks to judge progress through the planning process. A timeline of the recent events involved with the community's master plan is shown in Figure 11. The leaders of the tribe are hoping that a comprehensive community master plan will enable their tribe to fix some of the problems their tribe is currently facing, while retaining ties to their traditions and history.

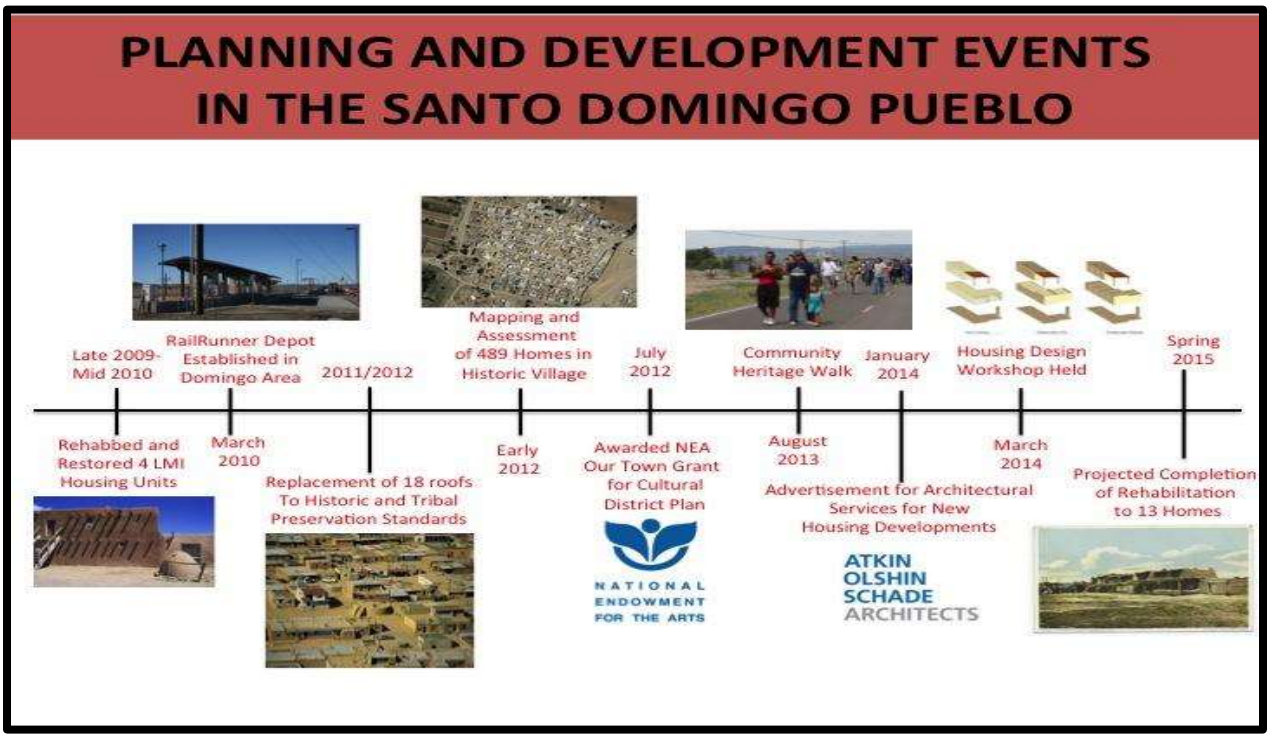


Figure 11: Timeline of Planning and Development in Santo Domingo

2.5.1 Acquiring Funds for Master Plan

One of the most significant federal acts for the Pueblos that impacted their living conditions has been the Native American Housing Assistance and Self Determination Act (NAHASDA) of 1966. This Act created federal assistance for housing programs through the Indian Housing Block Grant (IHBG), rather than having several separate funding programs. This

[86] National Endowment for the Arts 2015
[87] United States Department of Housing and Development 2013 p. 16

funding is provided by the Department of Housing and Urban Development (HUD) to provide low-income and underprivileged families of tribal communities with affordable housing.[88].

The funding for projects within Santo Domingo comes from various sources: Indian Community Development Block Grant Program's Imminent Threat grant, the NEA "Our Town" Program grant, a grant from Enterprise Community Partners Inc., the BIA Housing Improvement Program (HIP), the Mortgage Finance Authority HOME funds, and other similar organizations and government programs[89]. In 2012, the tribe received a $100,000 grant to create a new cultural district for the reservation in order to promote cultural and artistic entrepreneurship[90]. The Santo Domingo Pueblo have made great strides to updating their village and increasing the quality of life while still maintaining their cultural traditions.

2.5.2 Community Buildings

Recently, the tribe has started implementing new projects to benefit all community members as part of their Master Plan. In 2010, Atkin Olshin Schade Architects made news for its state of the art safety complex in Kewa. The complex services the fire department, police force, and Emergency Medical Services Department. The complex combined new technology with the aesthetic of the pueblo. Embodying the traditional style, there is a living space of the complex that has an earth floor and a central living area. It also employs glass that is highly insulative and harvests rainwater for fire training and irrigation[91].

Figure 12: Kewa Safety Complex[92]

The Santo Domingo Trading Post is another recent development project for the community members. The building, which suffered extensive damage from a fire in 2001, has undergone restoration since 2009, when a stop for the Rail Runner Express was established at

[88] Native American Assistance and Self Determination Act of 1996. edited by U.S. Department of Housing and Urban Development.
[89] United States Department of Housing and Development 2013 p. 6-7
[90] National Endowment for the Arts 2015
[91] Weideman 2011
[92] http://www.aosarchitects.com/images/gallery/SD%20FS%2039_ext%20dusk.jpg

the pueblo[93]. The funds to support this project have come from federal grants and include $511,118 awarded from the United States Economic Development Administration to complete phase II of the restoration[94]. The goal of restoring the Santo Domingo Trading Post is to allow economic development and increased tourism.

Figure 13: Restoration of the Santo Domingo Trading Post[95]

2.5.3 Housing Projects

Another significant component of the Master Plan is the housing rehabilitation that has been performed. In recent years, the SDTHA has partnered with different organizations to address the housing needs of the Santo Domingo Pueblo and allocate the proper resources to execute a plan. In 2009, the Sandoval County "Empowering our Communities" helped to complete the rehabilitation of five Low to Moderate Income (LMI) households. The process of rehabilitating these buildings involved dealing with the hazardous and unsanitary conditions along with restoring building systems such as the plumbing and electrical components and the roofs' structural systems.

A couple of years later in 2011, a similar project was executed with the help of a 2011 Imminent Threat Indian Community Development Block Grant (ICDBG) after about 70 homes suffered severe destruction following a hailstorm. This project initially entailed the replacement of eighteen roofs to historic and Tribal preservation standards using careful restoration techniques to preserve the existing adobe walls. The efficient cost saving plan during the project allowed six more homes to undergo the same repairs in 2013.

Another significant housing project was funded by the Bureau of Indian Affairs (BIA) Housing Improvement Program in 2012 to serve as a Historic Preservation trial for future developments by testing preservation techniques on adobe walls and two-story homes. The

[93]http://www.santafenewmexican.com/life/features/santo-domingo-pueblo-restores-historic-trading-post/article_aed1b0a0-8132-55e3-8994-8d34c4ee2dce.html

[94] http://krwg.org/post/udall-heinrich-announce-nearly-800000-economic-development-new-mexico

[95]http://bloximages.newyork1.vip.townnews.com/santafenewmexican.com/content/tncms/assets/v3/editorial/8/42/842647d1-db94-58a1-bea8-783dc815d33e/548cc4f8e7875.image.jpg?resize=760%2C507

home was rehabilitated to Housing Quality Standards by stabilizing the walls, replacing the roof, windows, and walls, and upgrading the plumbing, heating, and gas systems.

The SDTHA has accumulated experience from these projects,and has used their expertise to plan to completely rehabilitate the fourteen LMI homes that received new roofs in 2011 to 2012. The goal is to meet Housing Quality Standards, Tribally adopted rehabilitation standards, and the New Mexico State Historic Preservation Office Standards, as well as the Mortgage Finance Authority's (MFA) Green Building and visitability standards.[96] Applications for federal funding have been accepted and the homes are expected to be completed by early spring of 2015. Santo Domingo's comprehensive planning for housing improvement has allowed past projects to meet guidelines such as a completion on time, within budget, and according to the implementation schedule.

2.5.4 Santo Domingo's Need

The Santo Domingo Pueblo could use assistance in guiding their community Master Plan and we plan to aid as much as we can with our project. Upon our arrival, the Atkin Ohsin Schade (AOS) Architects provided us with a collection of housing data that we thought needed more organization. The Santo Domingo Tribal Housing Authority (SDTHA) is another organization working on the planning of the Santo Domingo Pueblo that needed a tool to aid in their future planning projects for Santo Domingo. The SDTHA had a basic foundation of a 3D model of the Pueblo, but the physical model needed to be developed further using 3D modelling and printing. After all the research and work we have done, our team thought it would be useful to come up with our own proposal on what we believe the AOS Architects and the SDTHA should plan for in the future. Only so many buildings within a certain budget can be rehabilitated in the Santo Domingo Pueblo each year so, we acted upon the evident need to select which homes needed to be rehabilitated first. The steps our team took to address these issues we found in Santo Domingo are outlined in the preceding section. We believe that addressing all of these problems will allow the development of the Santo Domingo Community Master Plan to take a step forward.

[96] United States Department of Housing and Development 2013 p. 4

3. Methodology

The objective of this project was to assist the Santo Domingo Tribal Housing Authority and Santo Domingo Tribal Planning Department to develop planning tools that will help create and maintain a long term plan for housing rehabilitation. Our project consisted of the following objectives:

1. Organizing existing housing data from the completed building surveys to create visualizations that can support strategic planning.
2. Creating digital and physical 3D models of the historic Village.
3. Developing planning tools to assist in future housing rehabilitation projects.

Our project took place within the historic Village of the Santo Domingo Pueblo in Sandoval County, New Mexico. The deliverable GIS data, which used an aerial view of the Village, and 3D models are all up-to-date, while the housing rehabilitation projects we are supporting will span approximately five years. We will be using data collected by Tribal youth in 2014. Additionally, we utilized the data provided to us by Atkin Olshin Schade Architects (AOS) which included the GIS building footprints.The following sections provide details for how the project objectives were completed.

Figure 14: The Santo Domingo Main Historic Village[97]

[97] Google Earth 2015

3.1 Organizing Housing Data

In order to create a long-term rehabilitation strategy for the Santo Domingo Pueblo, we compiled visual representations of data using GIS maps, graphs, and infographics. The purpose of this objective was to compile data that could be used at planning and tribal council meetings.

3.1.1 Organizing Completed Surveys

Many of the buildings in the historic village were already surveyed prior to our arrival using the Pueblo of Santo Domingo Historic Building Inventory Form, which was produced by the SDTHA, and is shown in Appendix A. The surveys were completed by Tribal youth working with AOS Architecture. The surveys have two sections; Section A could be completed by inspecting the exterior of the building, while Section B had to be completed with a resident of the home. Section A of the survey includes the building identification, building style, exterior construction, and physical condition. Section B asks questions pertaining to the building's use, resident information, interior quality, prior housing authority assistance, and maintenance history. There are approximately 400 buildings within the historic Village. At the time of our arrival approximately 166 buildings had completed surveys for both Section A and Section B, while 14 of them only had Section A complete.

Using GIS, we created a color-coded map to display the survey status of each building. This helped us determine which buildings still needed both sections or Section B only. It also displays if they did not require any further surveying due to prior denial to participate in Section B of the survey or if the Santo Domingo Pueblo deemed the building culturally significant and therefore did not want it to be surveyed by outsiders of the tribe. This initial map, shown in Figure 15, was created before we performed any building surveys and displays the completion status for building surveys. The surveys were scanned in digitally and organized in the network drive, indicating the family's name, if the home was inhabited, and if the family refused to complete Section B of the survey.

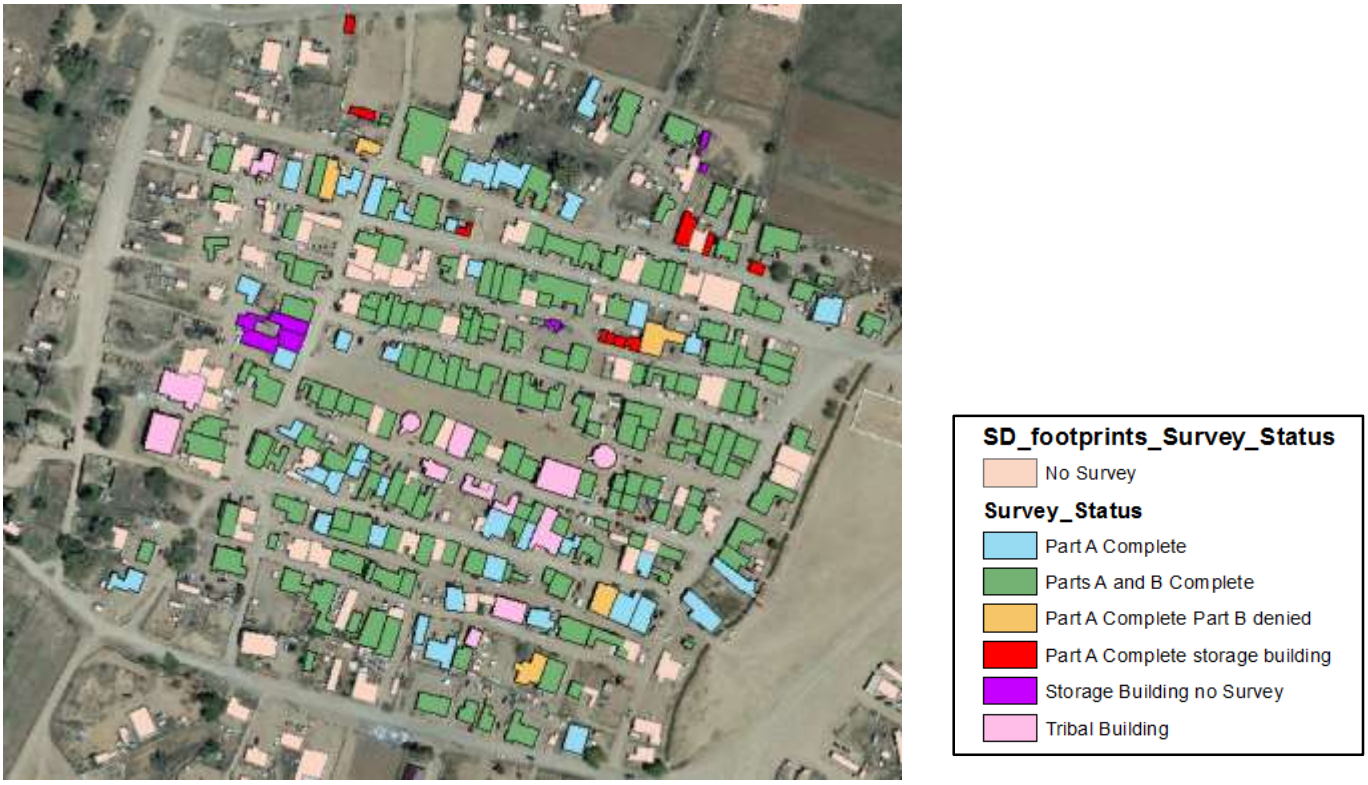


Figure 15: GIS Map of Building Survey Completion Status

3.1.2 Generating GIS Maps

AOS already had GIS maps in ArcGIS for the historic Village of the Santo Domingo Pueblo. The maps comprised of the building footprints, Village boundaries, the boundary for the Historical District, and aerial photos. All of these components except the aerial photos are vector data sets stored as shapefiles, which is a format that stores geometric location and attributes in either a point, line, or polygon. In this case, the buildings were represented by polygons, but the shapefiles did not contain information identifying or characterizing the building. The data that needed to be associated with these files is called metadata and was collected from the building surveys.

First compared two maps of the historic Village that were previously surveyed by tribal youth to determine accurate subdivisions for each building. Using these GIS Files, we input the relevant information gathered from the housing surveys into the GIS layers to be digitally hosted by the file. The attribute fields established include the number of stories, assessed physical condition, footprint area, type of wall construction, presence of mold, record of maintenance, number of residents, and residential density. We generated individual layers to display each set of information separately with color-coded maps Each layer created is shown in the Results Section.

3.1.3 Preparing Housing Data Presentation

Once the GIS file layers were made, we created graphs which further analyzed and visualized the data contained in the GIS maps. These graphs contained all of the relevant information from the GIS files, but they were created to communicate the information in various ways to demonstrate the need for rehabilitation in Santo Domingo. In addition, we created a

PowerPoint presentation which the SDTHA, AOS Architects and the Santo Domingo Tribal Planning Department can use to present the housing data to Tribal Council in a way that would demonstrate why rehabilitation the Village would be beneficial to the Tribe.

3.2 Constructing Physical 3D Model of the Historic Village

The SDTHA had already constructed a routed elevation model of both the historic Village and the two new proposed housing developments prior to our arrival at the project site. The models were constructed so that plates of multiple housing blocks could be placed in the tray and removed to show various potential planning strategies for the Village.

3.2.1 3D Modelling the Buildings

Using the building footprints and the unit subdivisions from the GIS map, the historic Village was modelled using Rhinoceros 5 software. The GIS map was saved as a CAD file and imported directly into Rhinoceros. Small scale models were created from this map projected through a preexisting model of the topography of the village. The models contained an interior waffle pattern so that less material would be used during 3D printing. The buildings were modelled at 1:720 (or 1 inch equals 60 feet) scale, as specified by our sponsor. This scale contains few architectural details, but we did exaggerate parapets in order to visualize the separation between the different units within a housing block. The model was then split into smaller sections so it could be 3D printed.

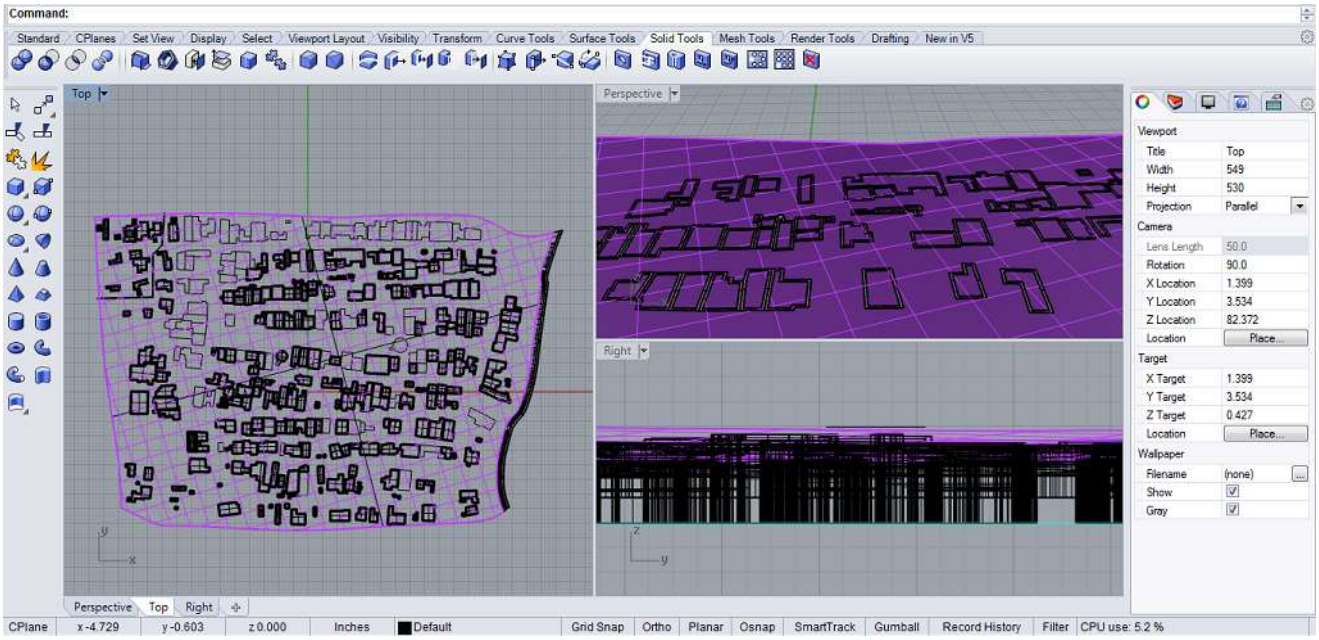


Figure 16: 3D Modelling Process

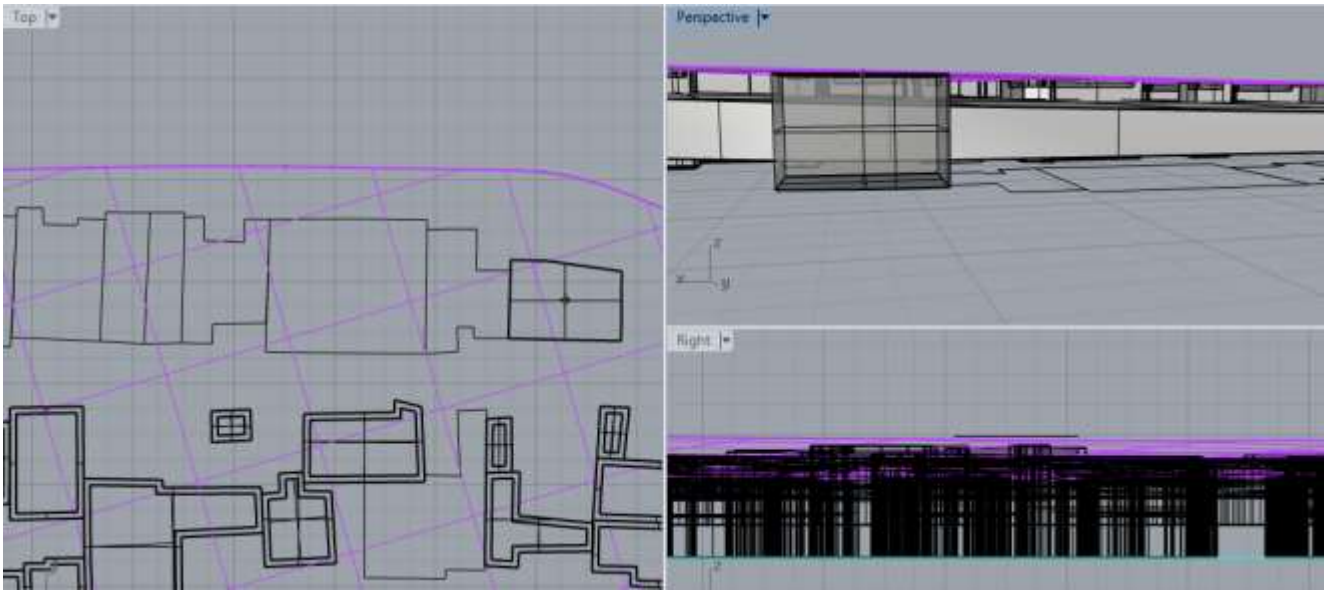


Figure 17: 3D Modelling Process

3.2.2 3D Printing the Village Sections

After the buildings were modelled in Rhinoceros, they were ready to be 3D printed. The village has a Formlabs 3D printer, which uses a process called stereolithography, a process of heating material and forming layers on top of each other by curing the liquid resin with a laser. The Formlabs printer can print layers that are .025mm thick, compared to a minimum layer thickness of .1mm for a similarly priced extrusion 3D printer.

The 3D models were saved as .STL files, and then opened in Preform. Perform 3D was used to read the .stl model, check for inconsistencies, add support material, and generate code that would be exported to the 3D printer. The printer was more likely to have an error if a print took longer than five hours, so the print files were made such that they would be completed after two to four hours.

Figure 18: Formlabs 3D Printer[98]

[98] http://cdni.wired.co.uk/620x413/o_r/printer-1.jpg

3.3 Creating Tools for Future Rehabilitation Projects

The final contribution that we made for our sponsor was a set of tools to help in future rehabilitation plans. We revised the survey created by AOS, created a visual assessment guide, a point system to rank the buildings, an algorithm to weight the point system, and cost estimates for the surveyed buildings. The point system is based on a 1-4 likert scale defining the building's characteristics in terms of how urgent it is to rehabilitate. A sample size of the tribe should then rank the order that they believe the houses should be rehabilitated in based on the points that they see are assigned. These resulting ranks can then be used in our weighting system to determine how much a particular characteristic should play a role in determining the rehabilitation selection. Using these tools, we created example 5 year rehabilitation plans to show how these tools could be implemented in the future.

3.3.1 Revising Survey Template

In pursuit of a housing rehabilitation plan, we revised the data collection phase to incorporate the most quantifiable information. Our plan involved adding prevalent information from the Housing Quality Standards that are established by the Department of Housing and Urban Development. Since this agency has been the primary source of funding, it was important to include their all of their assessment fields into the SDTHA building surveys. We aimed to improve the existing survey content by including a measurable scale for more categories. This will allow a more specific assessment of all components of the building, so that the prioritization for housing rehabilitation can be further refined.

3.3.2 Producing a Visual Assessment Guide

The revised building surveys were complemented by a visual guide that we created for future surveyors to use in order to assess the condition of the buildings in the pueblo. We produced this guide in order to promote consistency within the data collection processes of Santo Domingo. Pictures from the Ohkay Owingeh Preservation Project were used as references to give the most relevant example of a particular building condition, which was the main focus of the visual guide. We also included the identification of all building components and specific structural flaws that are attached to those components. This visual assessment guide was generated to rate all of the building features and gather a better scope for housing rehabilitation.

3.3.3 Establishing a Point System to Prioritize Rehabilitation

In order to prioritize which housing units had the greatest need for rehabilitation, it was necessary to create a point system, so it would be possible to select the homes with the greatest need to be rehabilitated first. It was modelled after one used during the Ohkay Owingeh Preservation Project. Housing units earned points based on a set of criteria that describe the structural condition of the building as well as criteria that are based on the occupants of the home (called use criteria). The higher point value the building has, the more likely it is that it will be rehabilitated. The structural criteria evaluates the unit's overall, roof, and wall condition, as well as the presence of mold. The building use criteria assesses the occupancy (full time vs. part time), record of maintenance, residential density, and the presence of young children, youth, and elderly. Each field is rated on a 1-4 scale , similar to Likert Scale, with the presence of mold, occupancy, and record of maintenance having less than four possible options due to

the limitations of the survey options. A typical Likert Scale is a 1-5 point range corresponding to Strongly Disagree, Disagree, Neither Agree or Disagree, Agree, Strongly Agree. The point systems for the structural criteria and building use criteria are shown in Table 1 and Table 2.

Table 1: Rubric for Structural Criteria

	4	3	2	1
Overall Condition	Severe	Poor	Fair	Good
Wall Condition	Severe	Poor	Fair	Good
Roof Condition	Severe	Poor	Fair	Good
Mold	Present	N/A	N/A	Not Present

Table 2: Rubric for Building Use Criteria

	4	3	2	1
Youth (6-17)	>/= 50%	>/= 25%	<25%	None
Elderly (55+)	>/= 50%	>/= 25%	<25%	None
Young Children (0-5)	>/= 50%	>/= 25%	< 25%	None
Occupancy	Full-Time	N/A	N/A	Part-Time
Density (sf/person)	<150	<500	<800	>800
Record of Maintenance	Complete	Partial	N/A	None

3.3.4 Creating a Weighting Formula for the Point System

Because some criteria may be more important than other criteria, we created a weighting system to be used with the points system. It is important to separate the facts of the rubric (the point value for each criteria) from values (how much each criteria should be worth).[99] Some people may believe that Density is a more important factor than the amount of Youth, and therefore should be weighted more, while others may think the reverse is true. It is important to survey people in the village to understand how the criteria should be weighted. The weighting system was made into a spreadsheet for the SDTHA to use. The guide on how to collect data for the spreadsheet and using the spreadsheet, the algorithm used by the spreadsheet, and an

[99] Adelman, Leonard, *Separation of Facts and Values* in “Human Judgement: the SJT View”, ch. 14, 1988

example of a completed sheet is in Appendix B. Once all of the criteria have been weighted, the new point system can be used along with cost estimates to determine the order in which buildings should be rehabilitated in the future.

3.3.5 Determining Costs to Rehabilitate Units

In order to easily sort buildings with similar costs per unit area, we assigned issue levels to each of the buildings with correctly completed surveys that used the unweighted point system. We classified units as “Minor”, “Moderate”, or “Major”. The levels were determined by considering the points earned based on the structural criteria . Table 3 shows the range of points a building must earn for each severity level. These issue levels will be used in the cost estimation of the buildings.

Table 3: Characteristics for Each Issue Level

Issue Level	Structural Criteria Points
Major	13-15
Moderate	8-12
Minor	5-7

All of the buildings with Part A of the Survey completed were then given a repair cost estimate. We used the direct cost per square foot estimates that Ohkay Owingeh used in their rehabilitation project in 2010 as a reference (See Appendix C). These values were multiplied by 1.0765 to account for inflation, as shown in Table 4. The unit cost was computed using the area of the buildings and an additional 50% of the direct cost to account for overhead and profit, general conditions, and contingency was factored in to determine the total estimated cost for each unit.

Table 4: Cost Per Square Foot

Issue Level	Unit Cost Used in Ohkay Owingeh Rehabilitation Project	Inflation Factor	Unit Cost Used in Santo Domingo Rehabilitation Plan
Major	$70.10	1.0765	$75.46
Moderate	$50.60	1.0765	$54.47
Minor	$39.30	1.0765	$42.30

3.3.6 Designing Example Five Year Plans

Using our rehabilitation tools, we created three example five year plans. The first plan only takes into account the unweighted structural criteria. This allowed for buildings that did not have Part B of the survey filled out to be considered. The second plan was based on the unweighted structural and use criteria. The point values for residential density were weighted by

2 and a third plan using the new weighted point values. The second and third plans were created to show how weighting certain criteria could change the order that buildings were selected for rehabilitation.

The preliminary criteria that the houses in the historic Village must meet are the standards provided by the Indian Housing Block Grant (IHBG) guidelines. One of the requirements is for the family's income to be less than 80% of the median annual income per family size in that area. The homes also must be owner occupied and be noncompliant with the HUD Housing Quality Standards (HQS). Since the income data for the residents of Santo Domingo is inaccessible, homes that were inhabited and had an overall condition stated as either severe, poor, or fair, qualified for the housing rehabilitation. Only homes meeting this criteria were used in our example 5 year rehabilitation plans.

The estimated award per year for the IHBG is $900,000. The SDTHA set the goal to rehabilitate no less than five buildings per year. The highest priority buildings based on the point system would be selected, granted that they could be renovated under budget and still fulfill the goal of at least five buildings per year.

4. Results

With aspirations of assisting in the future rehabilitation of the Santo Domingo Pueblo, we have created more organized housing data, a partially completed physical 3D model of the historic village, and various other planning tools as a result of our 14-week project. We believe that the Santo Domingo Tribal Planning Department, the AOS Architects, and the Santo Domingo Housing Authority will be able to use these results as tools to continue the rehabilitation of the Santo Domingo Pueblo. Also, we hope that these tools have planted seeds that can grow into other pueblo rehabilitation projects.

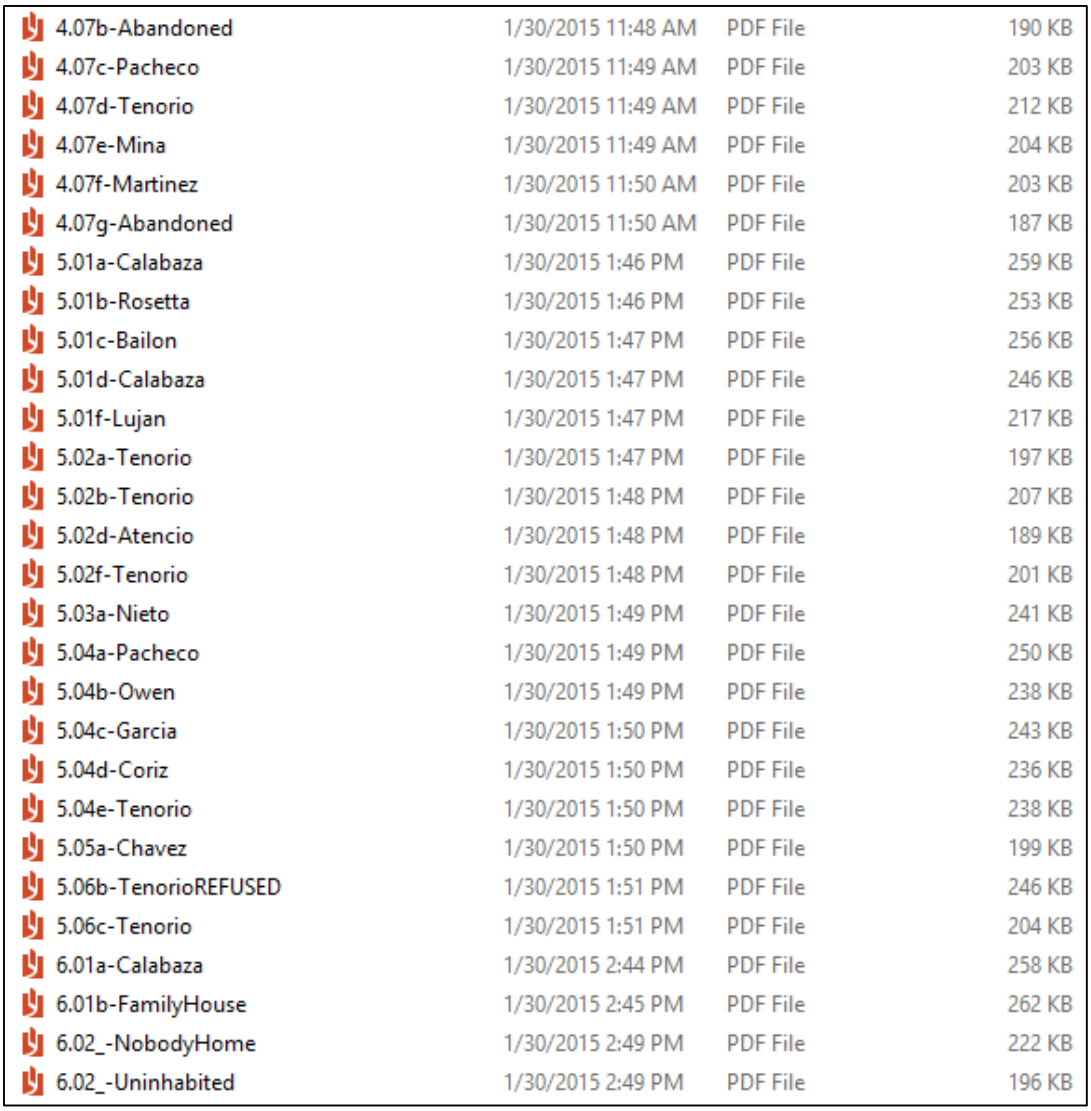
4.1 Organized Housing Data

The first step of our project was to organize the survey data that had been previously collected and make use of it. We did this by:

1. Digitally Cataloging the Survey Data
2. Creating Visualizations of the Survey Data
3. Developing a Web Application

4.1.1 Digitally Cataloging the Survey Data

Figure 19 shows the filing system used for organizing the housing data that had previously been created. This required digitally backing up the already completed paper surveys on the AOS Architects' server. AOS planned on working with Local Data, a data organization company, to create an easier way to implement data taken from future surveys. Our first task was to digitize all of the already collected data and organize it so that Local Data could then work with it. Each survey was scanned and saved as a PDF file. The naming system for the files refers to the survey of a specific house. The filename contains the unique number to the house, the subdivision, the family name, whether or not it is abandoned, and whether or not the family refused to complete the survey.

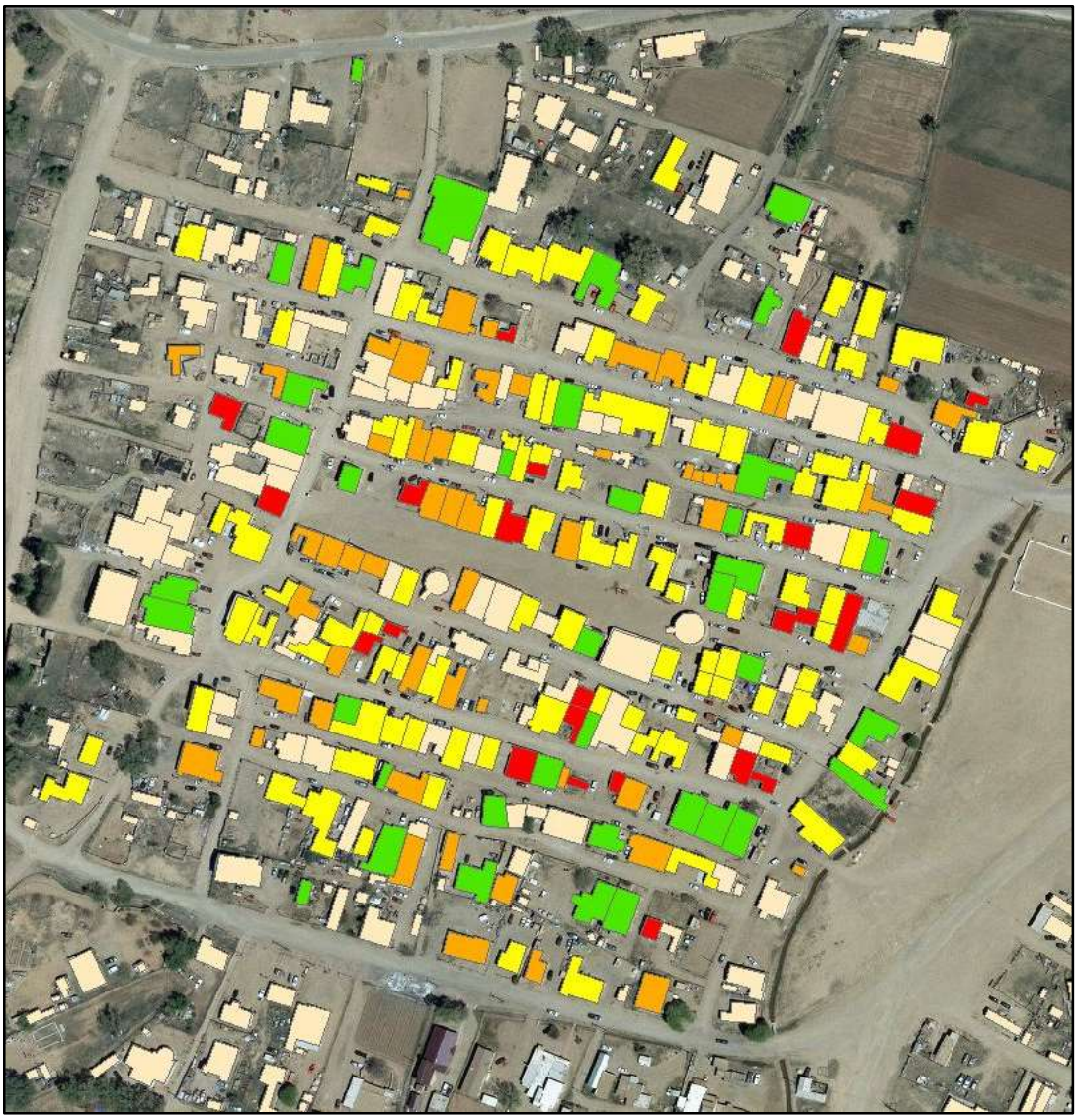


4.07b-Abandoned	1/30/2015 11:48 AM	PDF File	190 KB
4.07c-Pacheco	1/30/2015 11:49 AM	PDF File	203 KB
4.07d-Tenorio	1/30/2015 11:49 AM	PDF File	212 KB
4.07e-Mina	1/30/2015 11:49 AM	PDF File	204 KB
4.07f-Martinez	1/30/2015 11:50 AM	PDF File	203 KB
4.07g-Abandoned	1/30/2015 11:50 AM	PDF File	187 KB
5.01a-Calabaza	1/30/2015 1:46 PM	PDF File	259 KB
5.01b-Rosetta	1/30/2015 1:46 PM	PDF File	253 KB
5.01c-Bailon	1/30/2015 1:47 PM	PDF File	256 KB
5.01d-Calabaza	1/30/2015 1:47 PM	PDF File	246 KB
5.01f-Lujan	1/30/2015 1:47 PM	PDF File	217 KB
5.02a-Tenorio	1/30/2015 1:47 PM	PDF File	197 KB
5.02b-Tenorio	1/30/2015 1:48 PM	PDF File	207 KB
5.02d-Atencio	1/30/2015 1:48 PM	PDF File	189 KB
5.02f-Tenorio	1/30/2015 1:48 PM	PDF File	201 KB
5.03a-Nieto	1/30/2015 1:49 PM	PDF File	241 KB
5.04a-Pacheco	1/30/2015 1:49 PM	PDF File	250 KB
5.04b-Owen	1/30/2015 1:49 PM	PDF File	238 KB
5.04c-Garcia	1/30/2015 1:50 PM	PDF File	243 KB
5.04d-Coriz	1/30/2015 1:50 PM	PDF File	236 KB
5.04e-Tenorio	1/30/2015 1:50 PM	PDF File	238 KB
5.05a-Chavez	1/30/2015 1:50 PM	PDF File	199 KB
5.06b-TenorioREFUSED	1/30/2015 1:51 PM	PDF File	246 KB
5.06c-Tenorio	1/30/2015 1:51 PM	PDF File	204 KB
6.01a-Calabaza	1/30/2015 2:44 PM	PDF File	258 KB
6.01b-FamilyHouse	1/30/2015 2:45 PM	PDF File	262 KB
6.02_-NobodyHome	1/30/2015 2:49 PM	PDF File	222 KB
6.02_-Uninhabited	1/30/2015 2:49 PM	PDF File	196 KB

Figure 19: Naming System for Building Surveys

4.1.2 Creating Visualizations of the Survey Data

We created several color coded maps that visualize particular aspects of the survey over an aerial view of the historic village of Santo Domingo using ArcGIS software. The different maps and graphs we have created can be shown in Figures 19 through 28. The Santo Domingo Housing Authority and AOS Architects will be able use these maps to target specific buildings with particular conditions they want to address in rehabilitation. Using the collected data and maps, we created a presentation for the SDTHA to use when meeting with tribal council to gain support for future projects. This presentation contains infographics that illustrate the major trends within the village and demonstrate why rehabilitation projects could beneficial to the village. The presentation is in Appendix D.



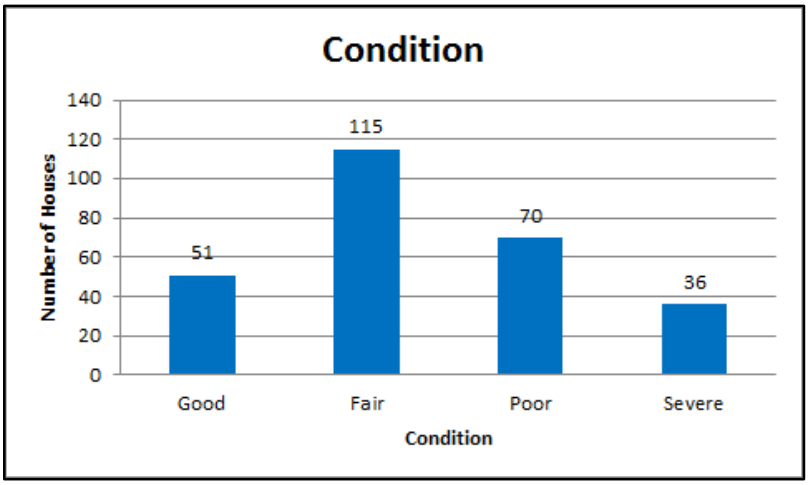
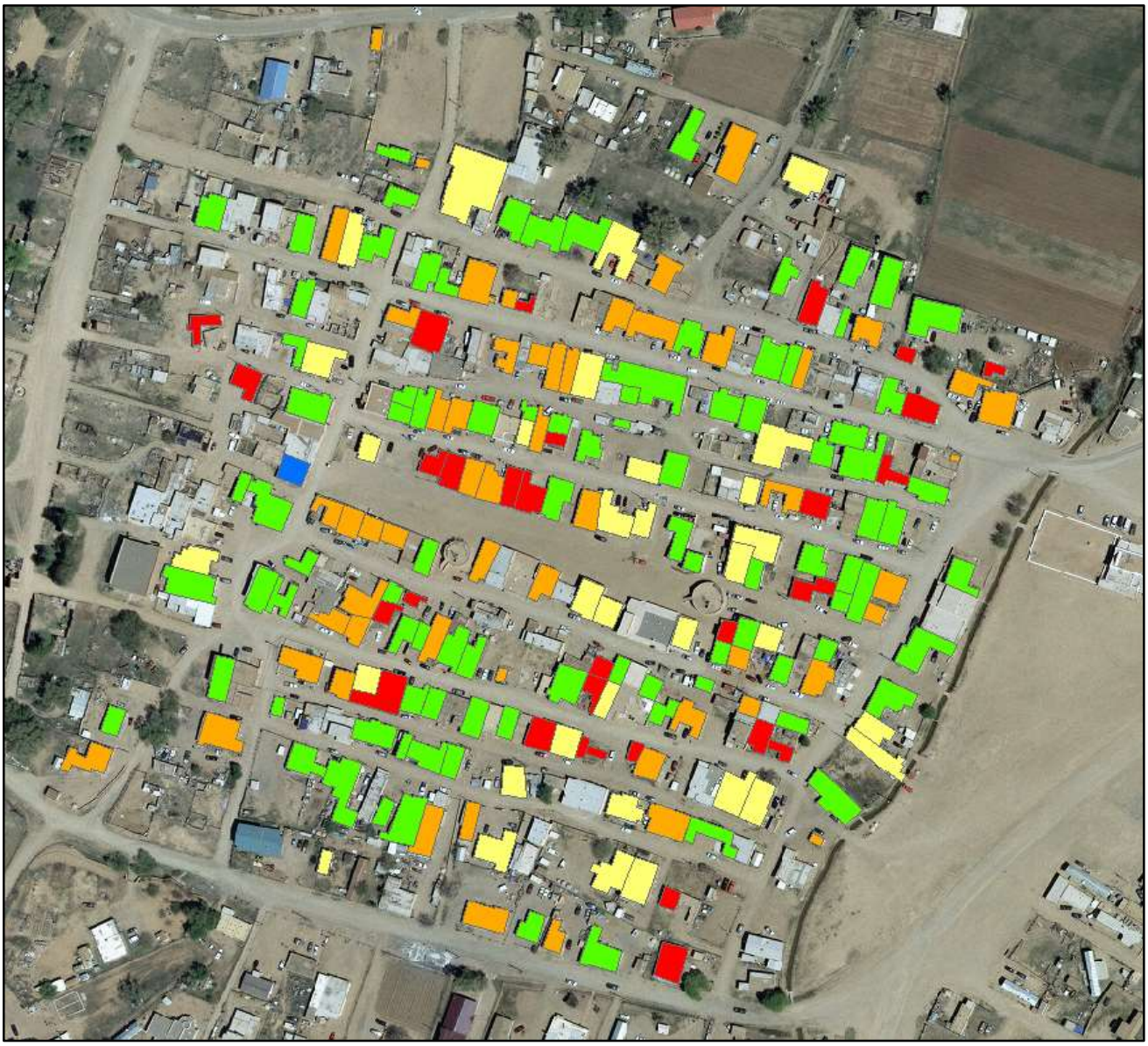
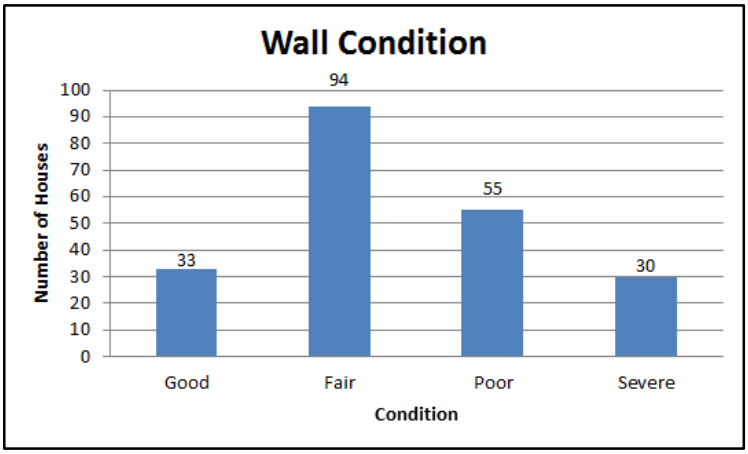


Figure 20: Condition of Buildings in the Historic Village





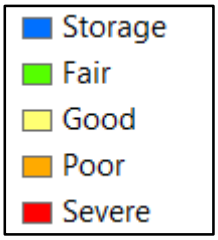


Figure 21: Wall Condition of Buildings in the Historic Village

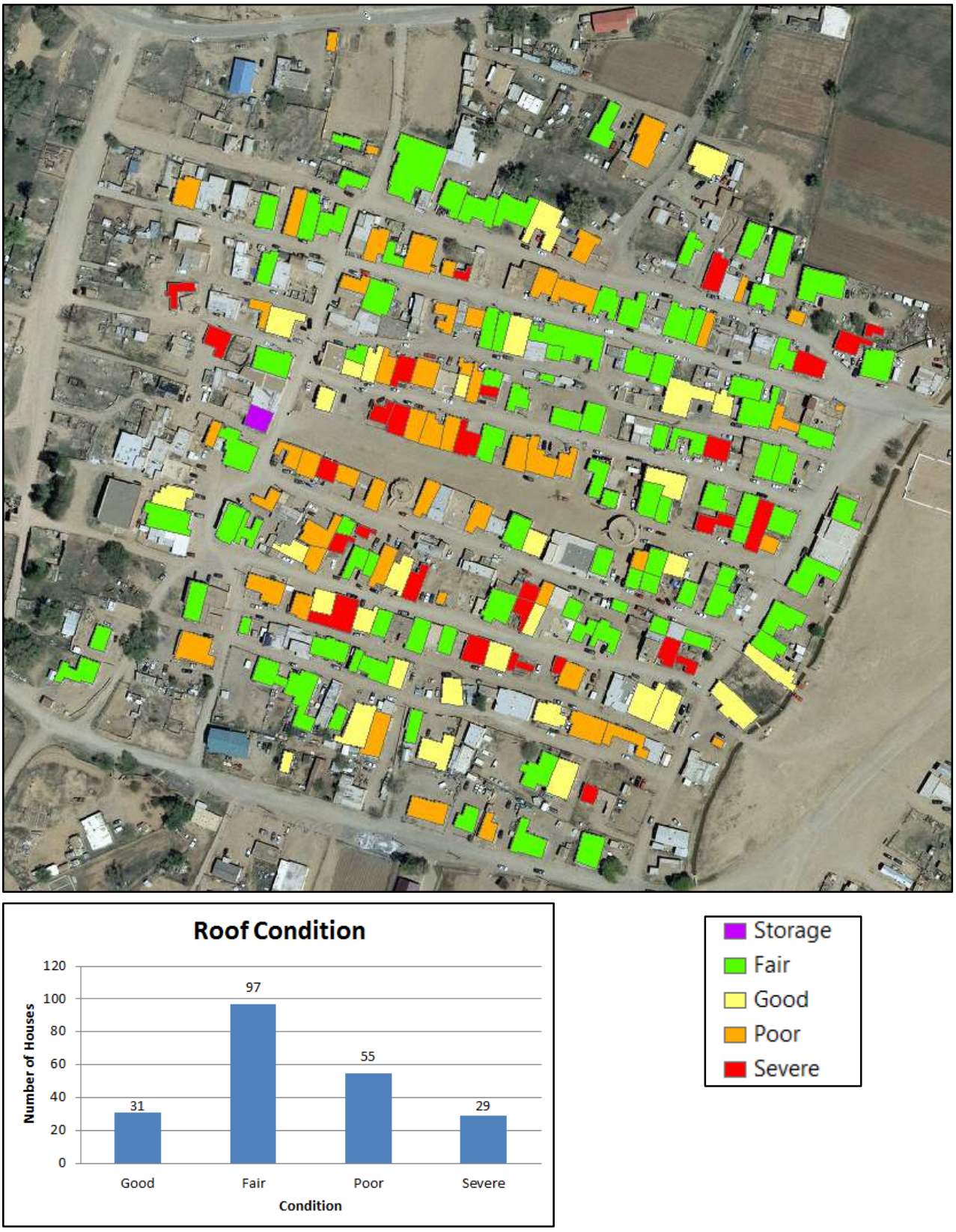


Figure 22: Roof Condition for Buildings in the Historic Village

Figures 20-22 show that about 30% of the buildings surveyed had poor or severe roof, wall, or overall condition. These maps also show that there is no specific area in the village that is in worse condition than the other areas. The buildings in poor and severe condition are spread throughout the village.

Figure 23: Number of Stories for Buildings in the Historic Village

Since buildings with two stories will cost more to rehabilitate, it is important to keep track of how many stories each building has. Two story buildings also pose a bigger threat as they deteriorate, causing more damage if they collapse.

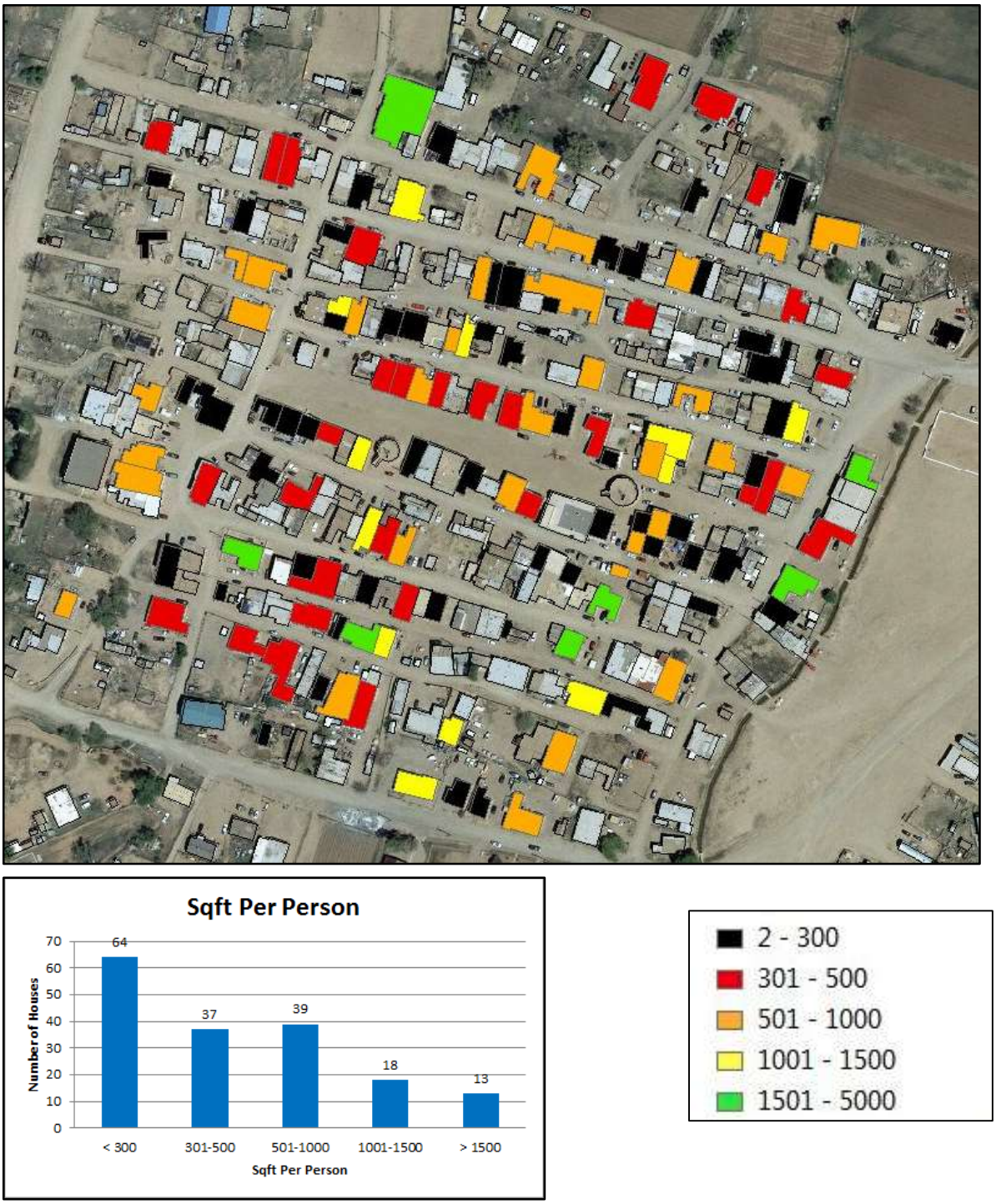


Figure 24: Area per Resident for Buildings in the Historic Village

Due to amount of buildings will low square foot per resident values, we decided this was a very important criteria to consider in deciding which buildings to rehabilitate.

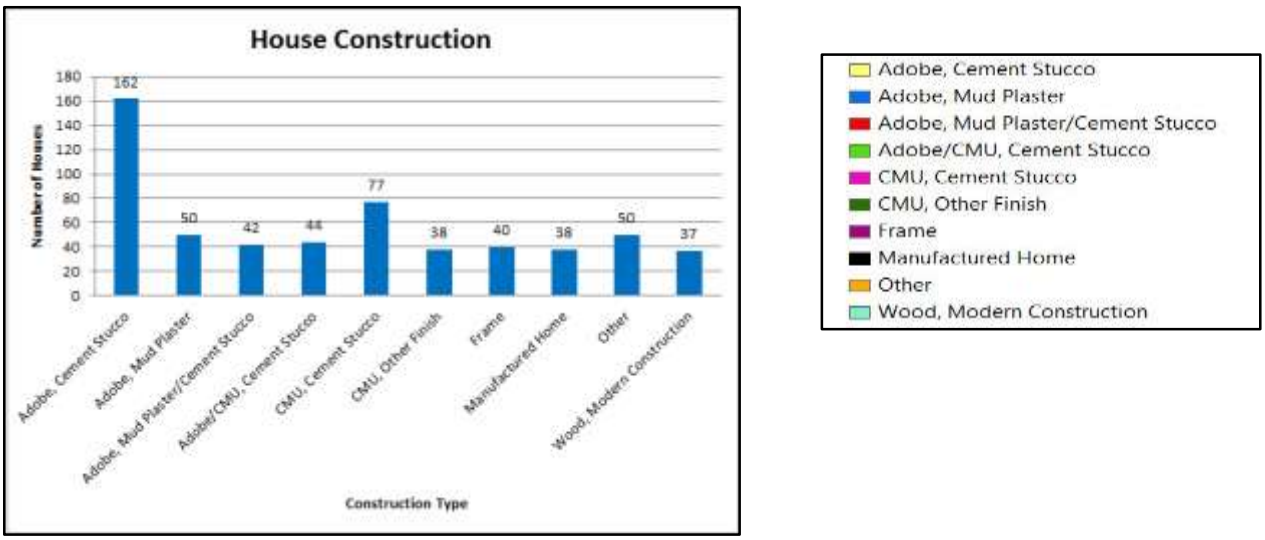


Figure 25: Wall Construction

Figure 25 shows that most of the buildings in the village have adobe walls with a cement stucco covering. The cement stucco has shown to cause problems such as coving as moisture

stored inside the walls. This figure shows that even if some of the cement stucco buildings are in good or fair condition now, they could deteriorate in the future, making the situation in the village even worse.

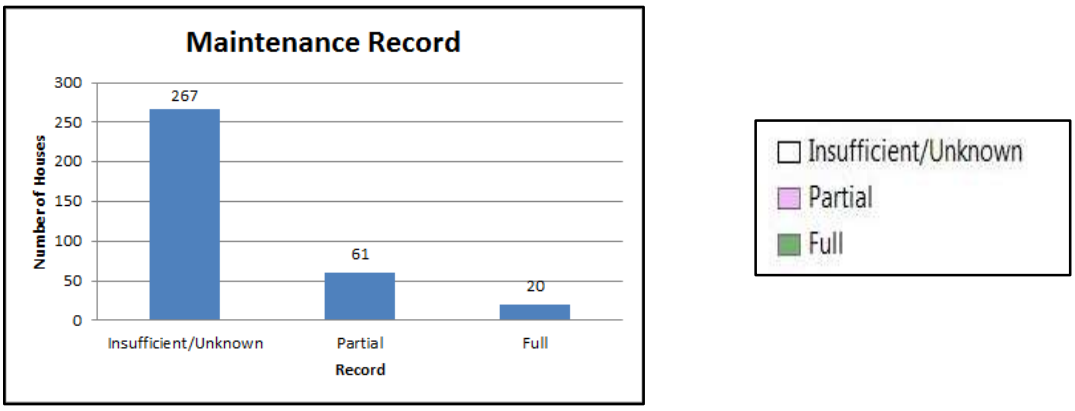


Figure 26: Maintenance Records

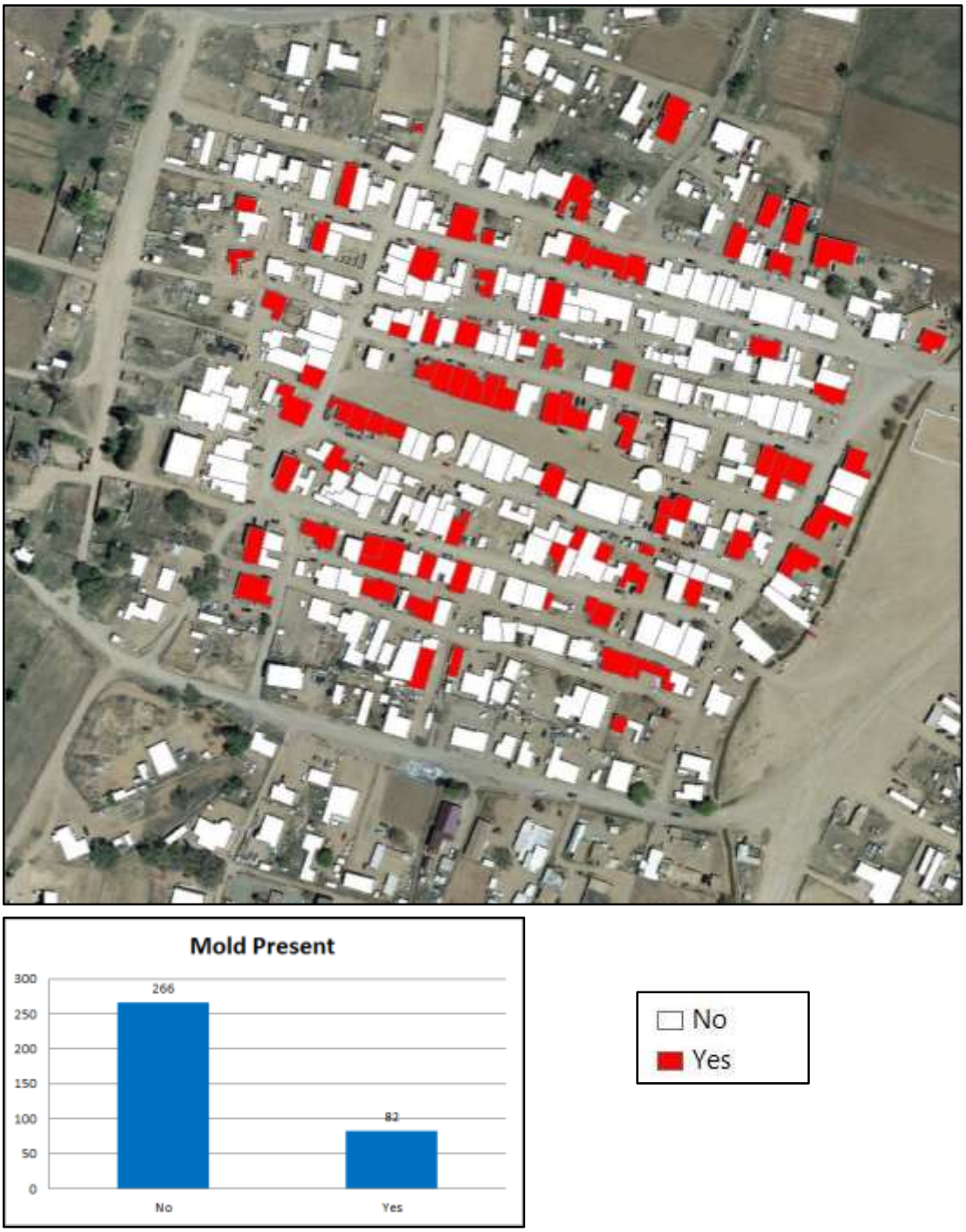


Figure 27: Mold Presence

If the surveys are extended in the future to catalog the health issues that each household has, such as asthma, Figure 27 could be used to prove the the mold has had serious health impacts on the residents. It could then be used to apply for more funding to help fix the mold issue in the Village.

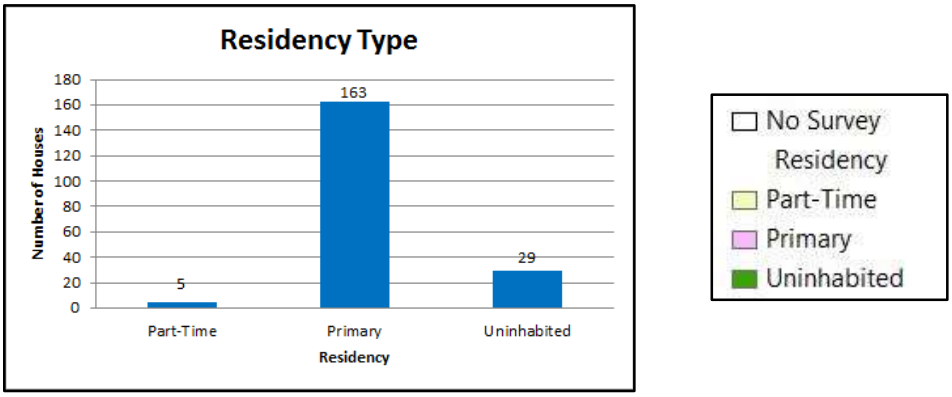


Figure 28: Residency

Figure 28 shows that unlike most other historic pueblos, the Santo Domingo pueblo use their Historic Village as a permanent housing district. It is important to rehabilitate the buildings that are a primary residency first.

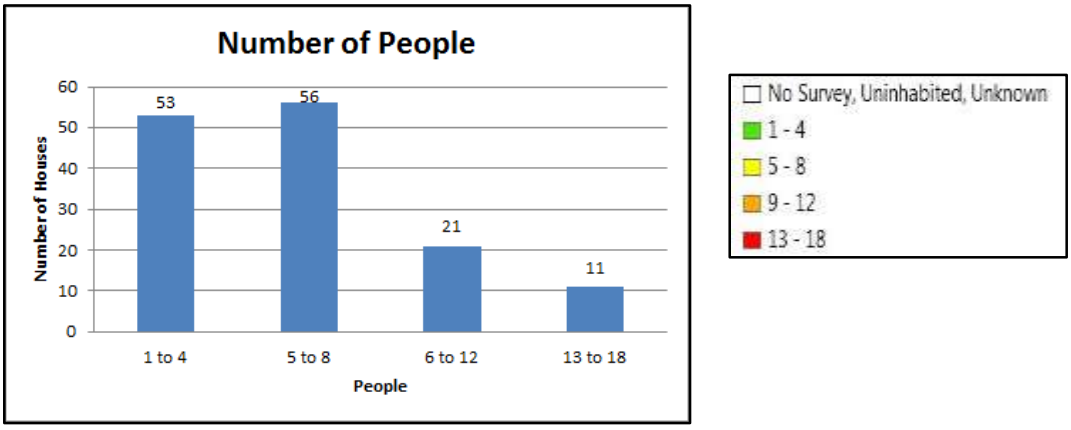


Figure 29: Number of Residents

Figure 29 shows that some of the smallest buildings in the village have the most residents, as many as 18. These buildings, as a result, have some of the lowest square foot per resident values.

4.1.3 Developing a Web Application

To further help the STDHA, the GIS layers were uploaded online. A web application was created using the new online map. The goal of the application is to make it easier for the villagers of Santo Domingo to complete the form required to request that their house be rehabilitated. The rehabilitation request form requires not only personal information about the family living in the house, but also the structural condition of the house and reasons why it should be rehabilitated. The web application lists the relevant collected structural data for each building that has been surveyed in the village. The villagers will be able to click on their housing unit and have all of the information show up for them to use. Figure 30 shows a screenshot of

the application.

Figure 30: GIS Web Application

4.2 Physical 3D Model of the Historic Village

The SDTHA already had a physical model of the terrain of the historic village, so we modelled all of the buildings of the village and then 3D printed as many sections as we could to place on the terrain. Figure 31 shows the part of the Historic Village that we were able to 3D print. The completed 3D model of the entire village will serve as a visual tool for the SDTHA to plan future rehabilitation projects for Santo Domingo. When giving presentations to Tribal Council, the SDTHA could project some of the GIS maps we have created or other images on top of the printed model. This will help give Tribal Council a better visual understanding of the situation of the Historic Village, making it more likely that the Housing Authority could get funding to rehabilitate the area. A guide on how to split the models into smaller pieces was written in case some of the unprinted models ever needed to be cut up. It discusses two different methods and can be seen in Appendix E.

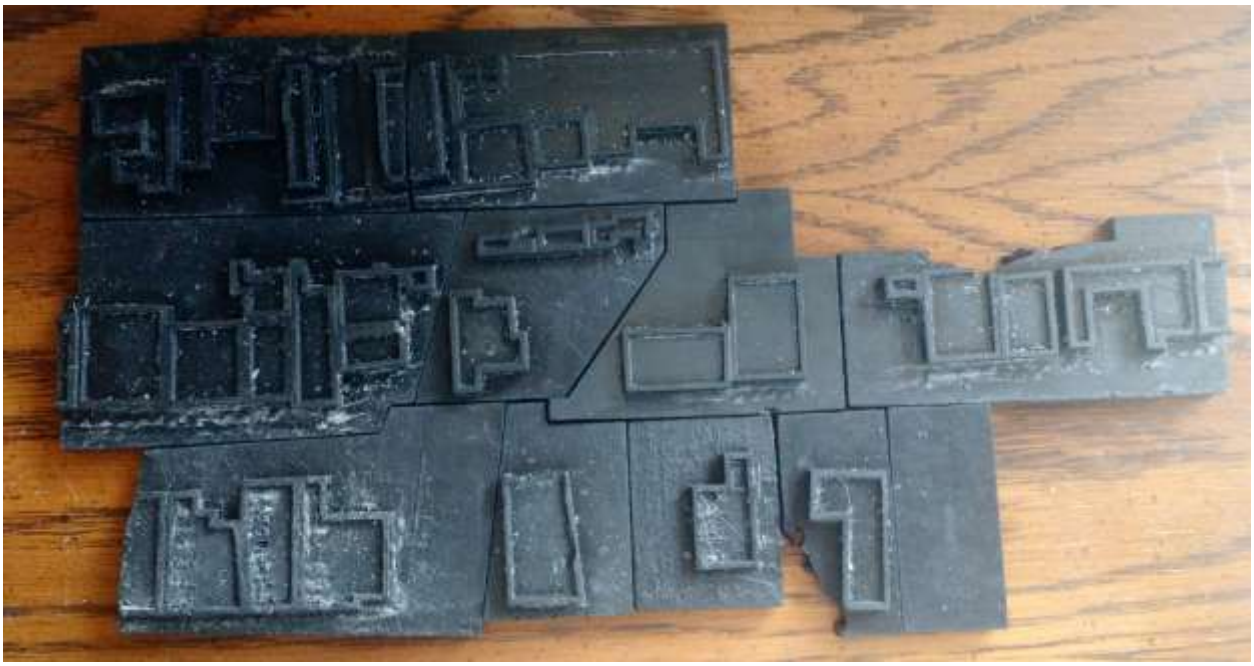


Figure 31: 3D Printed Part of the Historic Village

4.3 Tools to Plan for Future Housing Rehabilitation

Housing rehabilitation in the historic village of the Santo Domingo Pueblo is a continuous process that requires long term planning strategies. The planning must be adaptive to account for the change in tribal leadership as well as unexpected factors related to funding and potential natural disasters. In order to achieve these goals the following planning tools were created:

1. Refined Building Survey Form
2. Visual Building Assessment Guide
3. Five Year Rehabilitation System

4.3.1 Refined Building Surveys

The building surveys were revised to parallel the Housing Quality Standards (HQS) enforced by the Department of Housing and Urban Development. This was necessary since Santo Domingo's main funding source for housing comes from the IHBG, which requires buildings to be renovated to these standards. In order to encompass more information from the HQS, additional sections were added to the surveys such as interior condition and hazardous conditions. These categories included ceiling and floor conditions, as well as lead paint and signs of infestation. Other revisions made to the survey involved quantifying as much information that was possible. Using a one to four likert scale in other planning tools, it was important to add this concept to the assessment of exterior building components such as window, door, and foundation conditions. The scale was also applied to the previously mentioned interior features and the presence of mold, which was considered a significant factor while analysing the completed building surveys. Certain sections of the existing surveys were removed due to the lack of consistency in the completed surveys. This included the "Family Size" field which conflicted with the "Resident Ages" section in most instances. Since the number of residents counted in each field was different in several instances, it was concluded that removing one of the fields would eliminate confusion. Although the "Family Size" category revealed the relationships within the family, it is more important to classify the ages of the residents, and thus it was logical to keep the "Resident Ages" section. The refined survey is shown in Appendix H, with all of the revisions made in red text. The revised survey form will help AOS and the SDTHA get a better understanding of the condition of each building, allowing them to make a more informed decision on which buildings to rehabilitate.

4.3.2 Visual Building Assessment Guide

The visual building assessment guide was created as a supplementary form to the building survey in order to provide consistency when different people assess the condition of similar buildings. The guide comprises of photographs that are used to evaluate the condition of different building components. Building roofs, walls, foundations, doors, and windows of severe, poor, fair, and good conditions are included in the guide. The guide also includes the type of doors and windows a building has such as either metal, vinyl, or wooden. The visual assessment guide will make the surveys completed later on more consistent. It will also make it

possible to verify the previous surveys that were completed. A sample of the guide is shown in Figure 32 and the entire document can be found in Appendix I.

4.3.3 Five Year Rehabilitation System

In order to select which houses were to be rehabilitated first, we used the unweighted points system we had created. The units highlighted in red denote failure to qualify for rehabilitation due to being in good condition or uninhabited. The map shown in Figure 32 geographically displays which buildings were assessed for the proposed structural and building use criteria based on the qualifications for rehabilitation, which entailed being inhabited and assessed for an overall condition less than good.

Figure 32: Qualified Homes

Using the Structural and Use criteria we created, each housing unit was given a point value. The table showing the total unweighted points for each building is shown in Appendix J and Table 5 shows our proposed five year plan based off of the unweighted criteria and the cost analysis for each housing unit (See Appendix M).

Table 5: Five Year Plan for Unweighted Structural and Use Criteria

Year 1		Year 2		Year 3		Year 4		Year 5	
Unit	**Cost**	**Unit**	**Cost**	**Unit**	**Cost**	**Unit**	**Cost**	**Unit**	**Cost**
7.03 C	**$106,172.22**	**6.02 F**	**$212,797.20**	**7.02 C**	**$394,919.91**	**7.01 A**	**$280,145.25**	**6.08 E**	**$78,763.62**
13.09 A	**$140,808.36**	**1.03 C**	**$338,664.48**	**3.01 M**	**$84,728.09**	**3.02 A**	**$121,495.34**	**18.09 A**	**$161,775.90**
3.01 F	**$201,478.20**	**5.04 A**	**$211,665.30**	**2.01 D**	**$240,621.23**	**1.04 A**	**$182,855.79**	**5.01 A**	**$165,710.16**
5.01 C	**$291,351.06**	**10.1 A**	**$100,088.63**	**1.03 D**	**$163,410.00**	**4.02 B**	**$207,477.27**	**4.07 E**	**$293,841.24**
2.01 A	**$151,108.65**	**16.03 A**	**$32,825.10**			**3.01 C**	**$83,257.40**	**15.06 C**	**$243,018.93**
Total:	**$890,918.49**		**$886,959.20**		**$870,638.43**		**$845,869.48**		**$888,979.33**
Leftover:	**$9,081.51**		**$13,040.80**		**$29,361.57**		**$54,130.52**		**$11,020.67**

To show how the plan could change depending on how the criteria was weighted, we weighted the density category by a factor of two. We then created another five year plan based on the new point values. Tables 7 show the changed proposal, while the table of buildings and their corresponding point values are shown in Appendix K.

Table 6: Five Year Plan for Weighted Structural and Use Criteria

Year 1		Year 2		Year 3		Year 4		Year 5	
Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
7.03C	$106,172.22	5.01C	$291,351.06	1.03C	$338,664.48	5.01A	$165,710.16	6.08E	$78,763.62
13.09A	$140,808.36	2.01A	$151,108.65	10.10A	$100,088.63	2.01D	$240,621.23	5.5A	$77,980.05
3.01F	$201,478.20	1.04A	$182,855.79	3.01M	$84,728.09	4.02B	$207,477.27	1.01B	$165,942.86
6.02F	$212,797.20	3.02A	$121,495.34	1.03D	$163,410.00	5.06C	$175,338.93	7.02C	$394,919.91
5.04A	$211,665.30	13.04B	$148,539.70	3.01G	$172,724.37	3.01C	$83,257.40	18.09A	$161,775.90
				16.03A	$32,825.10				
Total:	$872,921.28		$895,350.54		$892,440.67		$872,404.99		$879,382.34
Leftover:	$27,079		$4,649		$7,559		$27,595		$20,618

Because there were some housing units that did not have Part B of the survey filled out, which is where the Use criteria was assessed, a third 5 Year Plan was created. The plan was generated using only the Structural criteria and the cost analysis for each housing unit. This allowed for prioritization based on building condition, and therefore only required Part A of the survey to be completed. Tables 7 shows the Structural 5 Year Plan, while the corresponding point values can be viewed in Appendix L.

Table 7: Five Year Plan with Structural Criteria Only

Year 1		Year 2		Year 3		Year 4		Year 5	
Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
4.02 A	$137,752.23	3.01 F	$201,478.20	7.02 C	$394,919.91	17.02 C	$377,215.63	4.02 C	$203,402.43
7.03 C	$106,172.22	6.02 F	$212,797.20	1.02 A	$71,083.32	5.01 D	$148,278.90	5.04 A	$211,665.30
13.09 A	$140,808.36	5.01 C	$291,351.06	2.01 A	$151,108.65	5.01 B	$186,650.31	4.02 D	$218,003.94
4.02 B	$207,477.27	16.03 A	$32,825.10	7.01 A	$280,145.25	6.04 E	$198,195.69	7.04 A	$150,337.20
4.07 E	$293,841.24	5.01 A	$165,710.16					9.04 A	$108,036.70
Total:	$886,051.32		$890,213.04		$887,470.17		$897,810.70		$889,256.27
Leftover:	$13,948.68		$9,786.96		$12,529.83		$2,189.30		$10,743.73

5. Conclusion and Recommendations

We have successfully been able to assist the Santo Domingo Tribal Housing Authority (SDTHA) and the Santo Domingo Tribal Planning Department take steps forward in their plan for the long-term rehabilitation of the Santo Domingo Pueblo. Currently, the SDTHA is in the process of completing their full 3D model of the Village and selecting which homes are to be rehabilitated first. We 3D modelled the entire Village and successfully 3D printed a small portion of it using the FormLabs printer provided to us by the SDTHA. In order to allow the SDTHA to continue the printing process, we created two guides, shown in Appendix E and Appendix G, on how to alter the digital models, and a general guide on how to make the FormLabs 3D printer function more consistently. We also condensed the entirety of our research and data analysis into a final presentation to members of the SDTHA, the Atkin Olshin Schade Architects, and the Santo Domingo Tribal Planning Department. We presented all of the deliverables we created at the conclusion of our project and demonstrated our accomplishments to the organizations present. Lastly, we have made a second presentation that the SDTHA and Atkin Olshin Schade Architects can use for the purpose of proposing future ideas to tribal members of Santo Domingo.

5.1 Recommendations

For each objective in our report, we came up with a set of recommendations based on the results of our project. These recommendations are for AOS architecture, the SDTHA, and any future IQP team to be able to continue our work.

5.1.1 For Future Surveying of Santo Domingo

Unfortunately, our group was not able to survey buildings in Santo Domingo. There are still many buildings in the Historic Village that need to have entire or partial surveys completed. The data that is collected in the surveys could also be expanded. It would be beneficial to start collecting health information for the residents for each buildings. This could help find correlations to health issues being caused by people living in houses with mold for example. Along with health issues, the revised survey template in Appendix H contains more information relevant to the HQS at that are applicable when the housing rehabilitation project is federally funded. It also contains more questions that are answered using a likert scale. This data can show more housing trends when displayed in GIS, and will allow a more involved prioritization process. Since there is uncertainty in how consistent the building surveys have been, we recommend that the visual assessment guide is expanded and used by the tribal youth, so that their recognition of building components and conditions is equal. Whenever new data is collected, it should be added into the GIS map that we created during our project. It is also important to further develop the web application we made and make it available for use by Tribal members. The application could be expanded by a future IQP team to allow for Tribal members to request a new survey of their building, flag false information, or help them fill out the housing rehabilitation forms.

5.1.2 For Future 3D Printing of the Historic Village

Because of the issues inherent in using the Formlabs 3D printer, we decided to experiment with two other printing methods to test if they were better options. We tested the

MakerBot 3D printer from the Santa Fe Indian School as well as a 3D printing ordering service called makexyz. The results of all 3 methods were compared and discussed in Appendix F. We suggest that the SDTHA use a printing service like makexyz in the future. In case the the Formlabs printer continues to be used, we created a guide covering removing a print from the Formlabs printer, setting up to the next print, proper steps for curing the print, and various issues we encountered while using the printer and how we solved them. (See Appendix G).

5.1.3 For Future Housing Rehabilitation Planning

To develop the best possible rehabilitation plan for Santo Domingo, we recommend that AOS follow our weighting guide and use our weighting spreadsheet to get an accurate list of the highest priority buildings to rehabilitate. The advantage to the weighting system is that it gives each criteria a fair weight based on the point values of all the other criteria. It also removes point values outside of 1.5 standard deviations of the average value, stopping outlier values from skewing the results. The disadvantage is that the spreadsheet is currently limited to 10 buildings and 10 individuals, giving it a relatively low sample size. The sample size could be increased in the spreadsheet, but the calculations for the weights are built into the spreadsheet and are not easily expandable. Even if our weighting system is not used, some other weighting system needs to be implemented to get an understanding of what criteria is the most important. As new buildings are surveyed, they need to be given point values and added to the list of buildings to be rehabilitated. The point values are currently stored in the GIS map file with the rest of the survey data, making it easy to add new values and get a new priority list.

5.2 Conclusion

We have achieved our ultimate goal by assisting the Santo Domingo Tribal Housing Authority, the Santo Domingo Tribal Planning Department, and the Atkin Olshin Schade Architects take a step forward in their plan to rehabilitate the Santo Domingo Pueblo. The Deliverables we have left behind will serve as tools that will forge future planning projects in Santo Domingo. These tools may not be used in the exact way we envisioned but, the Santo Domingo Tribal Housing Authority, the Santo Domingo Tribal Planning Department, and the Atkin Olshin Schade Architects have voiced to us that we have created a great foundation that can be easily built on in the future. Our project potentially serves as a foundation to assist pueblos other than Santo Domingo as our deliverables could be used as guidelines for pueblo rehabilitation in general. Our team is confident that the seeds we have planted will grow into much bigger pueblo rehabilitation projects in Santo Domingo and, hopefully, other pueblos.

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Appendix A. Example Building Survey from Santo Domingo

PUEBLO OF SANTO DOMINGO HISTORIC BUILDING INVENTORY

Santo Domingo Tribal Housing Authority – Sandoval County, NM
DRAFT INVENTORY FORM – 3/17/2013, page 1

1. BUILDING IDENTIFICATION	
Building Name (i.e. Coriz Residence)	
Building Number (Row.Block.Building)	
"Street/Row" Name	
E911 Address (GPS Coordinates)	
Location in Historic District? *National Register District? Y or N* *Tribal Historic District? Y or N*	
Associated Building *Number:* *Description:*	*location plan*

2. BUILDING USE	
Private ___ *Residence – Primary* ___ *Residence – Part-time* ___ *Residence – Uninhabited* ___ *Storage* ___ *Kitchen* ___ *Workshop* ___ *Other* _____	
Tribal (This info is just for location) will not be shared with outside entities. ___ *Tribal Buildings* ___ *Tribal Administrative* ___ *Kitchen* ___ *Other* _____	*photo of front (north, east, west, south) elevation*

3. SIGNIFICANCE (CHANGE?? Or Take Out)
Notes:

4. SURVEY INFORMATION	
Date of initial survey	*Date of follow-up survey*
Resident Contact *Name*	*Resident Contact* *Phone #* *Mailing Address*
Primary Surveyor *Name* *Group Affiliation* *Address* *Phone* *Email*	*Secondary Surveyor* *Name* *Group Affiliation* *Address* *Phone* *Email*
Inclusion in Previous Surveys ___ *2013 Tribal Census* ___ *2012 Preservation / Education Project* ___ 1979 *Handbook of North American Indians* (map p.380) ___ 1974 Population, Contact, and Climate in the New Mexican Pueblos (aerial, p.55) ___ 1950 *Bird's Eye View of the Pueblos* (map p.69)	

5. RESIDENT INFORMATION *(if non-residential, indicate "n/a" in Head of Household)*					
	Name	Age	Sex	Disabled	Notes
Head of Household					
Occupant 2					
Occupant 3					
Occupant 4					
Occupant 5					

___ *not visible* ___ *at grade* ___ *raised*	
Chimneys/Vents ___ *masonry* ___ *visible heater flues* ___ *visible plumbing vents*	***Porches*** ___ *traditional* ___ *modern* ___ *location (N, E, W, S)* ___ *none*
Windows ___ *traditional* ___ *modern* ___ *wood* ___ *aluminum* ___ *vinyl* ___ *varies* ___ *insulated?*	***Exterior Doors*** ___ *traditional* ___ *modern* ___ *wood* ___ *metal* ___*glazed?* ___ *security/storm door* ___ *screen door*
Other exterior features:	

8. PHYSICAL CONDITION	
Overall Evaluation ___ *Good* ___ *Fair* ___ *Poor* ___ *Severe*	
Roof Evaluation ___ *Good* ___ *Fair* ___ *Poor* ___ *Severe*	
Wall Evaluation ___ *Good* ___ *Fair* ___ *Poor* ___ *Severe*	
Are there structural concerns?	*Additional photo showing condition – provide description*

Is the building endangered?	
Notes:	

9. DWELLING CONFIGURATION / QUALITY	
Number of bedrooms	*Notes:*
Working restroom? Y/N *Please describe:*	
Working kitchen? Y/N *Please describe:*	
Heat Source ___ *traditional fireplace* ___ *wood stove* ___ *gas stove* ___ *space heater* ___ *other:* _____ ___ *none*	
Electrical Working? Y/N *Please describe:*	
Is mold believed to be present?	

10. Maintenance History	
Housing Authority Assistance *When?* *Scope?*	*Notes:*
2012 Roof Replacement?	
2013 Roof Replacement?	

General Maintenance	
Prior Resident Improvements?	

Appendix B. The Weighting System

Weighting System Guide

This guide will serve to explain how to collect data that will be used in the Weighting Spreadsheet and how to enter data into the spreadsheet.

Collecting the Data

To determine how each criteria should be weighted, members of the tribe need to be surveyed. It would be best to survey members of the Tribal Council; a total of 10 people will need to be surveyed to complete the spreadsheet. It might also be beneficial to have two or three architects from AOS be part of the 10 people surveyed. Randomly choose 10 buildings that have had complete surveys (Parts A and B) taken and list all of the information from the Structural and Use Criterias for each building on separate sheets of paper. Have the ten people rank the 10 buildings from lowest priority to highest priority. Record the order that each person put the buildings in.

Inputting the Data into the Spreadsheet

Store the point values from each building for each criteria into the spreadsheet. The first building's data will go in cells O16 through O26. The second building's data will go in cells P16 through P26 and so on.

	Building 10	Building 9	Building 8	Building 7	Building 6
Overall Condition	2	3	2	3	2
Wall Condition	2	3	2	3	3
Roof Condition	3	3	2	3	2
Mold	1	4	1	4	4
Youth (6-17)	2	1	1	3	3
Elderly (55+)	3	3	3	2	1
Young Children (0-5)	1	1	1	2	3
Occupancy	4	4	4	4	4
Density (sf/person)	4	1	2	3	2
Record of Maintenance	4	1	3	3	3

Each column is given a number as seen in the image above. Column O is given the number 10 for example. For the first person surveyed, put the buildings in the order they decided on into cells B2 through K2. Input the column number into the cells **NOT** the building number from the surveys. B2 is where the highest priority building goes and K2 is where the lowest one goes. Repeat this for the rest of the people surveyed.

Ranking	Highest Priority									Lowest Priority
Person1	10	9	8	7	6	5	4	3	2	1
Person2	9	10	7	8	5	6	3	4	1	2
Person3	10	8	9	6	7	4	3	5	2	1
Person4	1	2	3	4	5	6	7	8	9	10
Person5	10	9	8	7	6	5	4	3	2	1
Person6	6	5	7	2	3	1	4	8	9	10
Person7	10	8	9	7	6	5	1	3	2	1
Person8	10	9	8	7	6	5	4	3	2	1
Person9	8	3	5	7	2	1	10	9	6	4
Person10	9	10	7	8	5	6	3	4	1	2

The resulting weights for each criteria based on the inputted data are in cells Q3 through Q11.

Overall Condition	130	78.66666667	1.653
Wall Condition	132.125	78.66666667	1.68
Roof Condition	137.125	78.66666667	1.743
Mold	137	78.66666667	1.742
Youth (6-17)	110	78.66666667	1.398
Elderly (55+)	140	78.66666667	1.78
Young Children (0-5)	78.66666667	78.66666667	1
Density (sf/person)	155.125	78.66666667	1.972
Record of Maintenance	142.9	78.66666667	1.817

In this example all of the buildings had the same occupancy level, so its point values were ignored.

Math Behind the Weighting System

For each Person

$n_i = i^{th} position\ building$

For each Criteria

$Z_{n_i} = Criteria\ for\ the\ i^{th} position\ building$

$$Preliminary\ Total\ of\ the\ Criteria\ = P = \sum_{i=1}^{10} (Z_{n_i} * i)$$

Totaled from all of the People Surveyed

For each Criteria

$$Preliminary\ Total\ of\ the\ Criteria = T = \sum_{K=1}^{10} P_K$$

$$Mean\ of\ Preliminary\ Total = M = \frac{T}{10}$$

$$Standard\ Deviation\ of\ Preliminary\ Total = S = \sqrt{\frac{1}{10}\sum_{u=1}^{10} (P_u - M)^2}$$

For each Criteria and each Person

P = Total of a certain criteria for a certain person

if $P < (M - 1.5 * S)$ or if $P > (M + 1.5 * S)$, set $P = 0$

For each Criteria

P = Total of the criteria for a certain person

Number of People whose survey is counted = C, starting at C = 0

For each $P > 0$, C is incremented

$$New\ Total\ of\ the\ Criteria = T = \sum_{v=1}^{10} P_v$$

$$New\ Mean\ of\ the\ Criteria = M = \frac{T}{C}$$

For each M, divide by the minimum M of all of the Criteria

$$\boldsymbol{Weight\ of\ The\ Criteria} = \boldsymbol{W} = \frac{\boldsymbol{M}}{\boldsymbol{min(M\ value)}}$$

Example of a Completed Spreadsheet

Ranking	Highest Priority									Lowest Priority
Person1	10	9	8	7	6	5	4	3	2	1
Person2	9	10	7	8	5	6	3	4	1	2
Person3	10	8	9	6	7	4	3	5	2	1
Person4	1	2	3	4	5	6	7	8	9	10
Person5	10	9	8	7	6	5	4	3	2	1
Person6	6	5	7	2	3	1	4	8	9	10
Person7	10	8	9	7	6	5	1	3	2	1
Person8	10	9	8	7	6	5	4	3	2	1
Person9	8	3	5	7	2	1	10	9	6	4
Person10	9	10	7	8	5	6	3	4	1	2

	Overall Condition	Wall Condition	Roof Condition	Mold	Youth	Elderly	Young Children	Density	Maintenance
Person1	128	132	140	136	111	141	74	153	154
Person2	144	147	147	184	115	136	83	139	130
Person3	132	133	146	133	114	149	66	157	154
Person4	129	136	124	151	135	108	95	162	128
Person5	128	132	140	136	111	141	74	153	154
Person6	133	140	125	172	139	106	102	157	136
Person7	123	127	135	121	99	137	82	158	156
Person8	128	132	140	136	111	141	74	153	154
Person9	122	125	118	124	104	139	77	148	133
Person10	144	147	147	184	115	136	83	139	130

Standard Deviation Results									
Person1	128	132	140	136	111	141	74	153	154
Person2	0	0	147	0	115	136	83	0	130
Person3	132	133	146	133	114	149	66	157	154
Person4	132	136	124	151	0	0	95	162	128
Person5	128	132	140	136	111	141	74	153	154
Person6	133	140	125	172	0	0	0	157	136
Person7	123	127	135	121	99	137	82	158	156
Person8	128	132	140	136	111	141	74	153	154
Person9	122	125	0	124	104	139	77	148	133
Person10	144	0	0	124	115	136	83	0	130

	Building 10	Building 9	Building 8	Building 7	Building 6	Building 5	Building 4	Building 3	Building 2	Building 1
Overall Condition	2	3	2	3	2	3	3	2	2	2
Wall Condition	2	3	2	3	3	2	3	3	2	2
Roof Condition	3	3	2	3	2	2	3	2	2	2
Mold	1	4	1	4	4	4	4	4	1	1
Youth (6-17)	2	1	1	3	3	2	4	3	3	1
Elderly (55+)	3	3	3	2	1	2	2	4	1	1
Young Children (0-5)	1	1	1	2	3	2	1	1	1	3
Occupancy	4	4	4	4	4					
Density (sf/person)	4	1	2	3	2	4	3	2	3	4
Record of Maintenance	4	1	3	3	3	3	3	1	1	3

Criteria	Mean	Standard Deviation	Number of Surveys Used	Total Points	New Mean
Overall Condition	131.1	7.593125546	9	1170	130
Wall Condition	135.1	7.519604008	8	1057	132.125
Roof Condition	136.2	10.43285409	8	1097	137.125
Mold	147.7	23.89351376	9	1233	137
Youth (6-17)	115.4	12.4739729	8	880	110
Elderly (55+)	133.4	14.41604045	8	1120	140
Young Children (0-5)	81	10.71862346	9	708	78.66666667
Density (sf/person)	151.9	7.766738197	8	1241	155.125
Record of Maintenance	142.9	12.31485102	10	1429	142.9

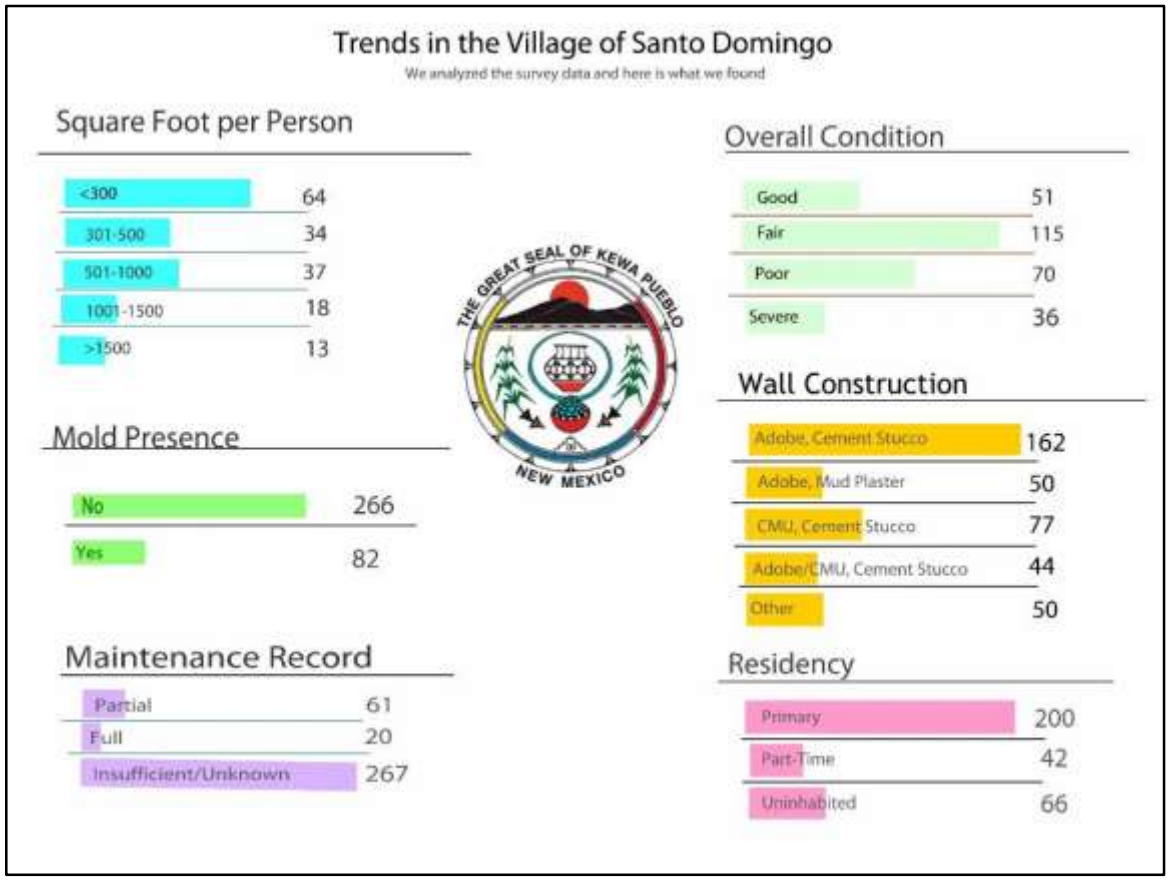
Total Criteria		Minimum Value	Weight Multiplier
Overall Condition	130	78.66666667	1.653
Wall Condition	132.125	78.66666667	1.68
Roof Condition	137.125	78.66666667	1.743
Mold	137	78.66666667	1.742
Youth (6-17)	110	78.66666667	1.398
Elderly (55+)	140	78.66666667	1.78
Young Children (0-5)	78.66666667	78.66666667	1
Density (sf/person)	155.125	78.66666667	1.972
Record of Maintenance	142.9	78.66666667	1.817

Appendix C. Owe'neh Bupingeh Preservation Plan

PRIORITIES		Unit	Owner	Severity of Issues	Size	HIGH				MEDIUM				# OF HIGH PRIORITIES MET	# OF MEDIUM PRIORITIES MET	COST ESTIMATING DETAIL				
						1 CURRENT INHABITATION-FT & RECENTLY MOVED OUT	3 RECORD OF MAINTENANCE	4 DWELLING CONDITION-POOR/SEVERE	5 ENDANGERMENT (the cause of OR in danger itself)	1 CURRENT INHABITATION - PART-TIME	2 FUTURE INHABITATION	4 DWELLING CONDITION-FAIR	6 LOCATION			Per SF Cost - Direct Costs Only	Per Unit	Overhead & Profit (10%)	Gen Conditions (10%)	Contingency (30%)
1a	1	301.139	Kelsey Medina	Major	1072	Y	Y	Y	Y		Y		Y	4	2	$ 70.1	75,141	7,514	7,514	27,051
1a	2	304.155	Justin Aquino	Major	1362	Y	Y	Y	Y		Y		Y	4	2	$ 70.1	95,468	9,547	9,547	34,369
1b	3	303d.150	Shawna Martinez	Moderate	650	Y	Y	Y	Y				Y	4	1	$ 50.6	32,922	3,292	3,292	11,852
2a	4	103.108	Richard Martinez	Major	874	Y		Y	Y		Y		Y	3	2	$ 70.1	61,262	6,126	6,126	22,054
2a	5	201.127 & 128	Mary M. Garcia	Major	1475		Y	Y	Y		Y		Y	3	2	$ 70.1	$ 103,389	10,339	10,339	37,220
2b	6	403c.163	Alisha Cata	Moderate	740	Y	Y	Y			Y		Y	3	2	$ 50.6	37,480	3,748	3,748	13,493
2b	7	403a.172	Povi Cruz	Moderate	1515		Y	Y	Y		Y		Y	3	2	$ 50.6	76,733	7,673	7,673	27,624
2c	8	101.101	Senida Gabaldon	Minor	2178	Y	Y		Y			Y	Y	3	2	$ 39.3	$ 85,526	8,553	8,553	30,789
2c	9	202a.125	Joseph C. Atencio Sr.	Minor	986	Y	Y		Y			Y	Y	3	2	$ 39.3	38,718	3,872	3,872	13,939
3	10	204.113	Michael Montoya	Major	1282	Y		Y	Y				Y	3	1	$ 70.1	89,861	8,986	8,986	32,350
3	11	304.152	John M. Cruz	Major	798	Y		Y	Y				Y	3	1	$ 70.1	55,935	5,594	5,594	20,137
4a	12	102.106	Eva Trujillo	Moderate	856	Y	Y					Y	Y	2	2	$ 50.6	43,356	4,336	4,336	15,608
4a	13	102.107	Dora M. Cruz	Moderate	1066	Y	Y					Y	Y	2	2	$ 50.6	53,992	5,399	5,399	19,437
4a	14	503.179	Elton Montoya	Moderate	1675	Y	Y					Y	Y	2	2	$ 50.6	84,837	8,484	8,484	30,541
4a	15	106.110	Benedict Aguino, Jr.	Moderate	1436		Y	Y			Y		Y	2	2	$ 50.6	$ 72,732	7,273	7,273	26,184
4b	16	603.611	Christina Chavez	Minor	2122	Y	Y					Y	Y	2	2	$ 39.3	83,327	8,333	8,333	29,998
4b	17	108.111	Rose Martinez	Minor	899	Y	Y					Y	Y	2	2	$ 39.3	35,302	3,530	3,530	12,709
4b	18	202a.121 & 122	Lisa Trujillo	Minor	1374	Y	Y					Y	Y	2	2	$ 39.3	53,954	5,395	5,395	19,424
4b	19	403c.161 & 162	Jeffrey Aguino	Minor	1364	Y	Y					Y	Y	2	2	$ 39.3	53,562	5,356	5,356	19,282
5a	20	902.200	Reycita Garcia	Moderate	1462	Y	Y					Y		2	1	$ 50.6	74,049	7,405	7,405	26,658
5b	21	303d.143 & 144	Art Cruz	Minor	1548	Y	Y						Y	2	1	$ 39.3	60,787	6,079	6,079	21,883
5b	22	305a.157	Jennie M. Salazar	Minor	1000	Y	Y						Y	2	1	$ 39.3	39,268	3,927	3,927	14,137
6	23	703.2	Iris Duran	Moderate	1094	Y	Y							2	0	$ 50.6	55,410	5,541	5,541	19,948
7a	24	504.181	Luberta Garcia	Moderate	673		Y			Y		Y	Y	1	3	$ 50.6	34,087	3,409	3,409	12,271
7b	25	202c.117	Fransisco Cruz *Grandson of Juanita Martinez* *Application Pending*	Minor	980		Y			Y		Y	Y	1	3	$ 39.3	38,483	3,848	3,848	13,854
7b	26	403c.164	Morison M. Bird-Romero	Minor	730		Y			Y		Y	Y	1	3	$ 39.3	28,666	2,867	2,867	10,320
7b	27	504.180	Nettie Cata (Marie Abeyta)	Minor	648		Y			Y		Y	Y	1	3	$ 39.3	25,446	2,545	2,545	9,160
7b	28	403a.173	Veronica Ortiz	Minor	973		Y				Y	Y	Y	1	3	$ 39.3	38,208	3,821	3,821	13,755

Appendix D. Presentation for Tribal Council

Slide #1



Building Overall Condition

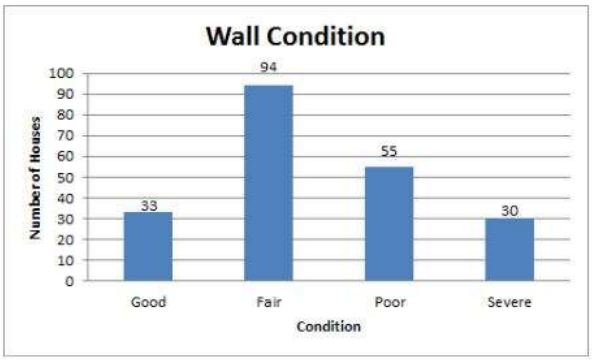
Good

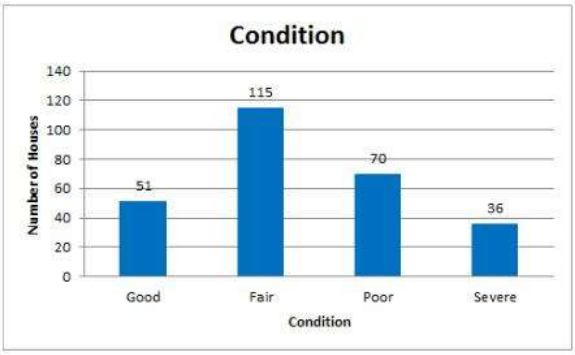
Fair

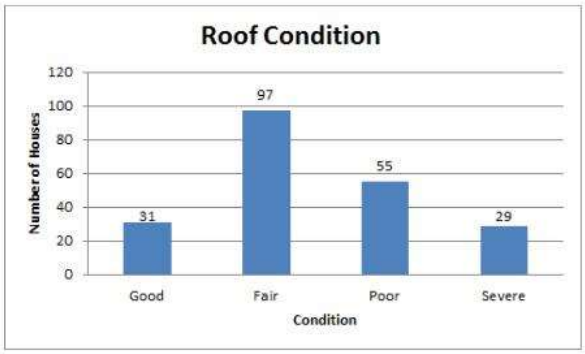
Poor

Severe

272 Units Assessed for Building Condition



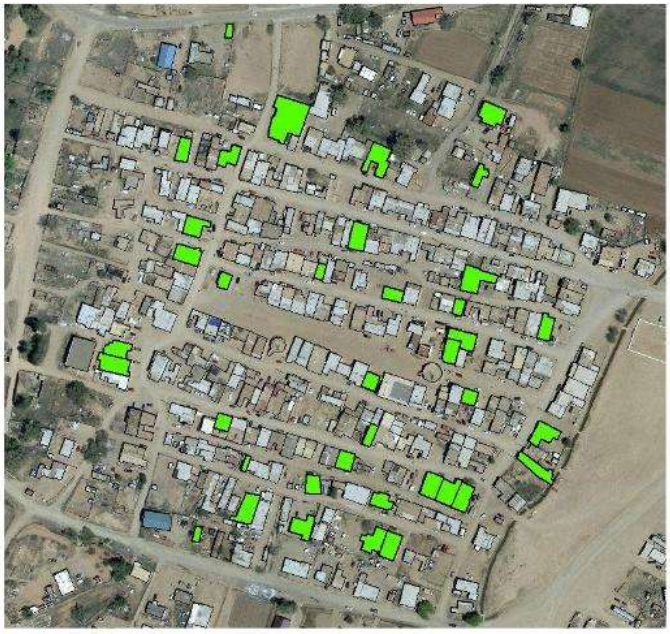




Good Condition

Signs

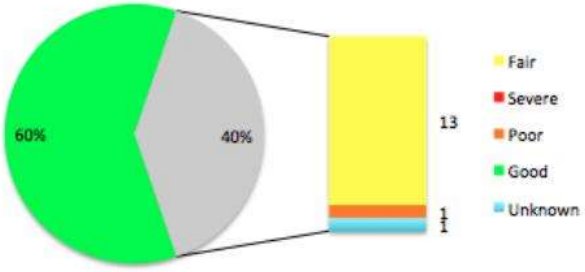
- No significant display of wall deterioration
- Building components (window and door) in good condition



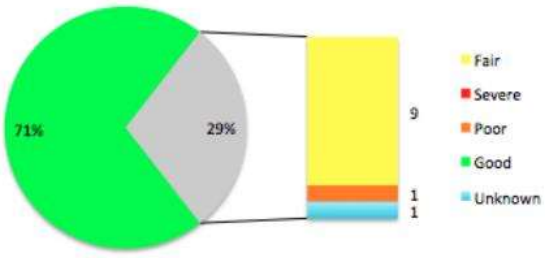
51 Units in Good Overall Condition

Good Overall Condition

Roof Condition



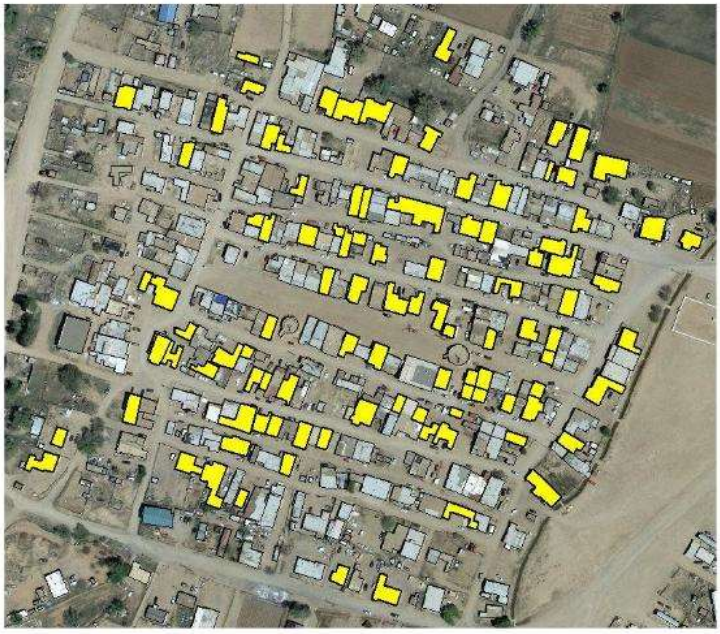
Wall Condition



Fair Condition

Signs

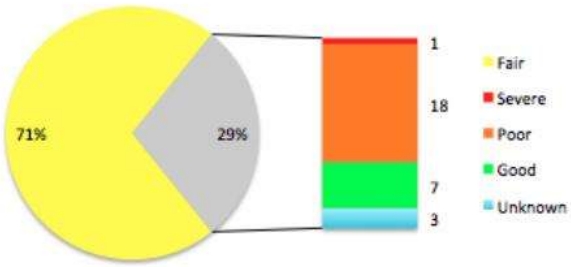
- Spalling looks present toward top of building
- Wall has minor visible deterioration



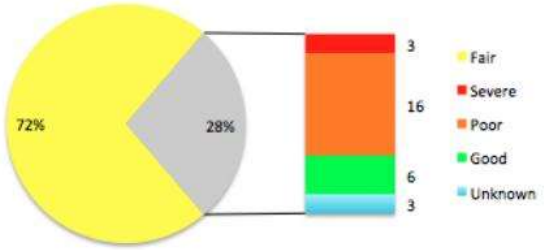
115 Units in Fair Overall Condition

Fair Overall Condition

Roof Condition



Wall Condition



Poor Condition

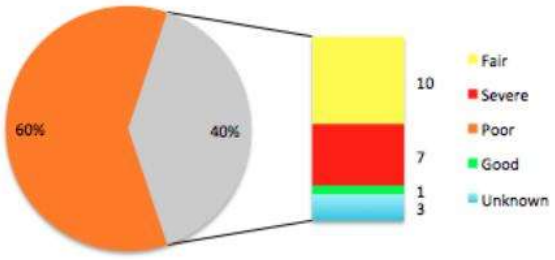
Signs

- Different surface coatings
- Windows in poor condition
- Roof deterioration is visible

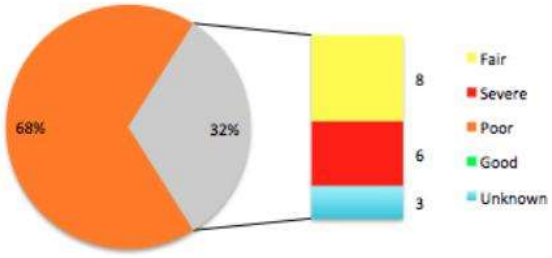
70 Units in Poor Overall Condition

Poor Overall Condition

Roof Condition



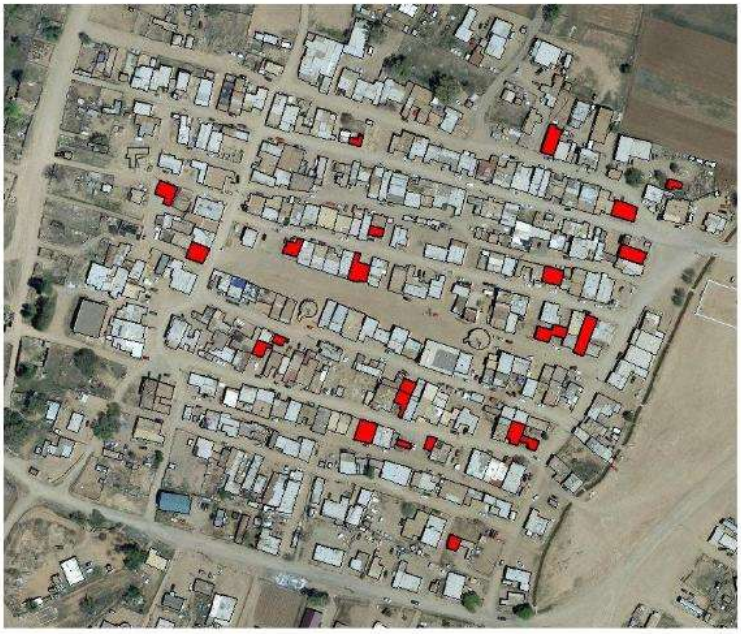
Wall Condition



Severe Condition

Signs

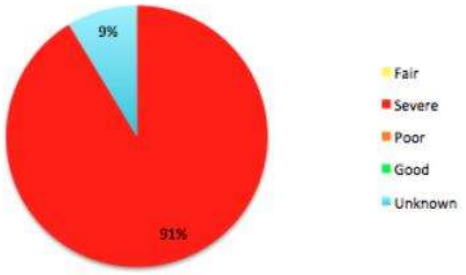
- Total Collapse of wall



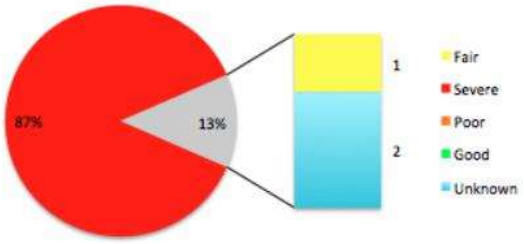
36 Units in Severe Overall Condition

Severe Overall Condition

Roof Condition



Wall Condition



Residency

Full-Time Residence

163

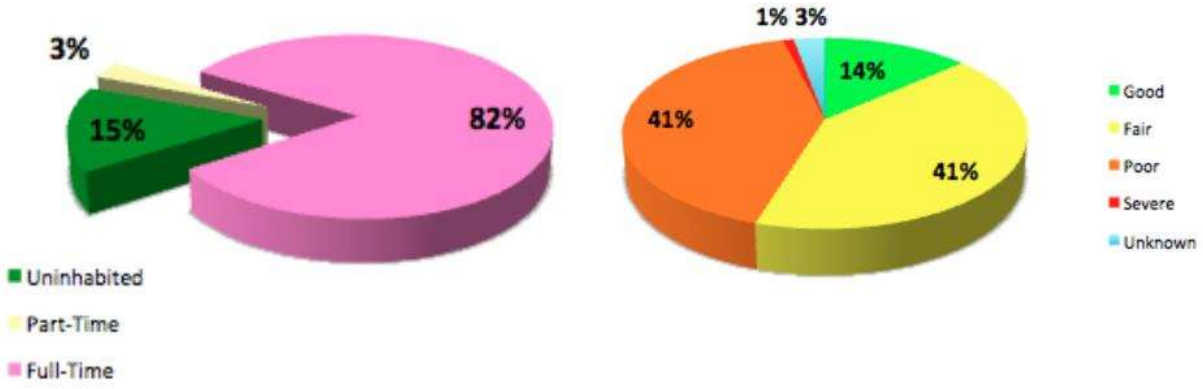
Part-Time Residence

5

Uninhabited

29

Building Condition for Full-Time Residences



Mold vs. Age of Residents

38 homes recorded with young children (0-5 years) living in them

Of these homes, **28** of them have mold present

72 homes recorded with elderly (55+ years) living in them

Of these homes, **38** of them have mold present

Record of Maintenance

Complete (20)

Partial (61)

Insufficient (128)

- Complete

B5. Maintenance History	Pre-2000	2000-2002	2003-2005	2006-2008	2009-2011	2012-2014
Roof	✓	✓	✓	✓	✓	✓
Ceiling	✓	✓	✓	✓	✓	✓
Ext. Walls		✓	✓	✓	✓	✓
Int. Walls		✓	✓	✓	✓	✓
Floors	✓	✓	✓	✓	✓	✓
Mechanical	✓	✓	✓	✓	✓	✓
Electrical	✓	✓	✓	✓	✓	✓
Plumbing	✓	✓	✓	✓	✓	✓
Mold	✓	✓	✓	✓	✓	✓

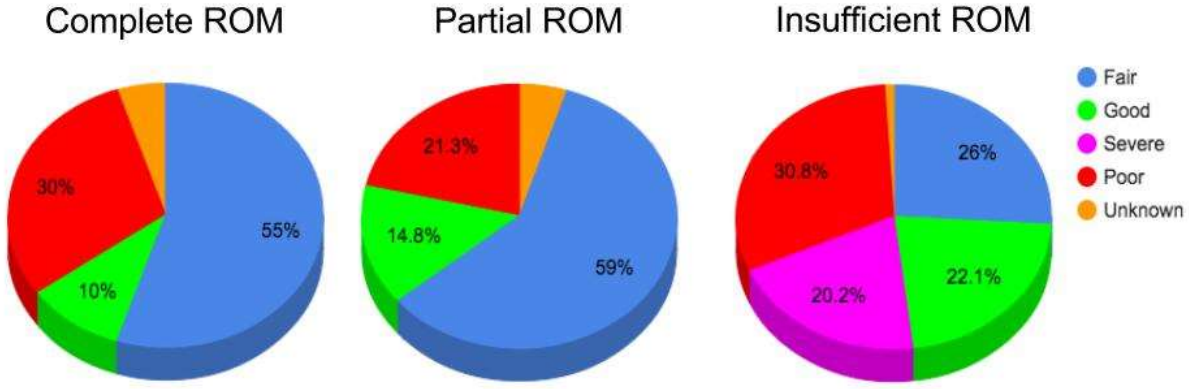
- Partial

B5. Maintenance History	Pre-2000	2000-2002	2003-2005	2006-2008	2009-2011	2012-2014
Roof						✓
Ceiling						✓
Ext. Walls						✓
Int. Walls						✓
Floors						
Mechanical						
Electrical						
Plumbing						
Mold						

- Insufficient

B5. Maintenance History	Pre-2000	2000-2002	2003-2005	2006-2008	2009-2011	2012-2014
Roof						
Ceiling						
Ext. Walls						
Int. Walls						
Floors						
Mechanical						
Electrical						
Plumbing						
Mold						

Building Condition vs. Record of Maintenance (ROM)



- The only homes with a severe building condition have insufficient Records of Maintenance

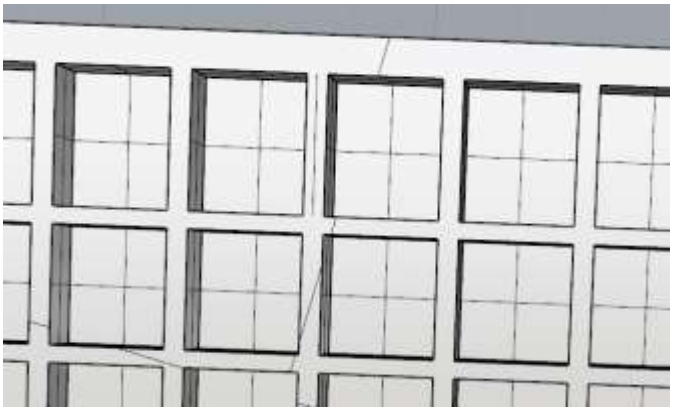
- Trend is not consistent; Buildings w/ partial ROM have a greater percentage of good and fair condition buildings than buildings with complete ROM

Appendix E. How to Split the 3D Model

Option 1:

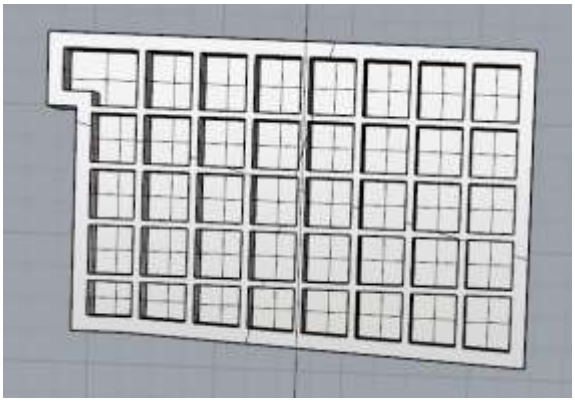
Select curve to offset (Distance=*0.03125* Corner=*Sharp* ThroughPoint Tolerance=*0.001* BothSides InCPlane=*No* Cap=*None*):

Offset an existing line



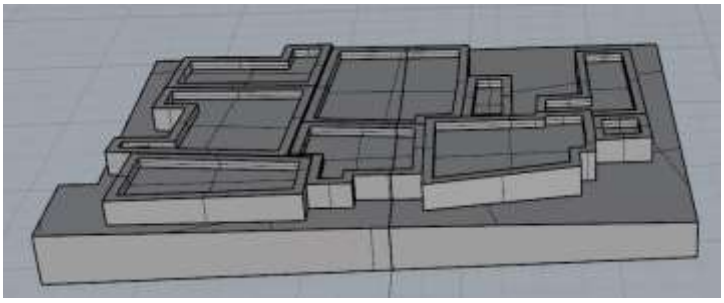
Command: Extend

Extend the line past the boundaries of the model



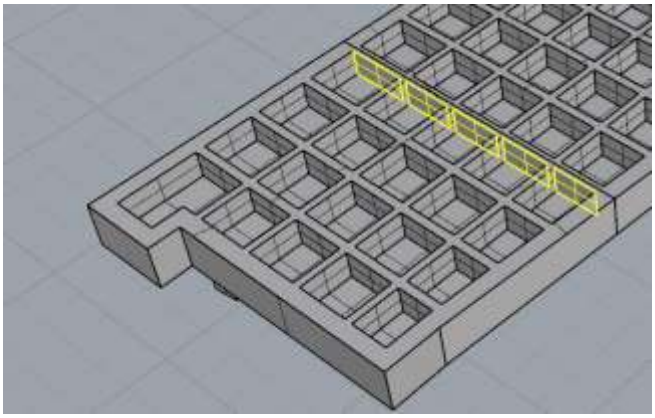
Command: WireCut

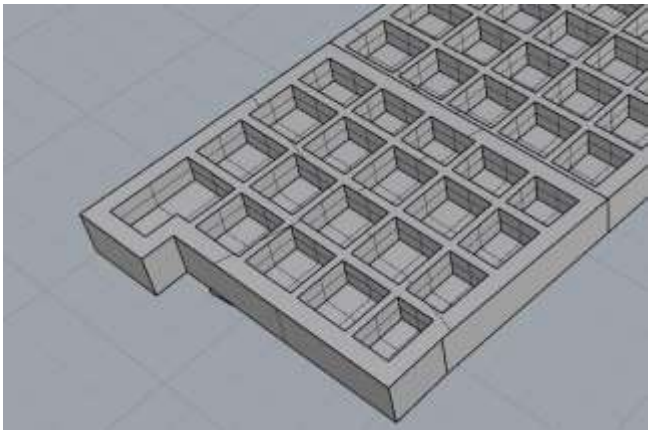
Cut the model into two pieces with the line



Command: MoveFace

Move the Faces of the new wall to increase the thickness for both models

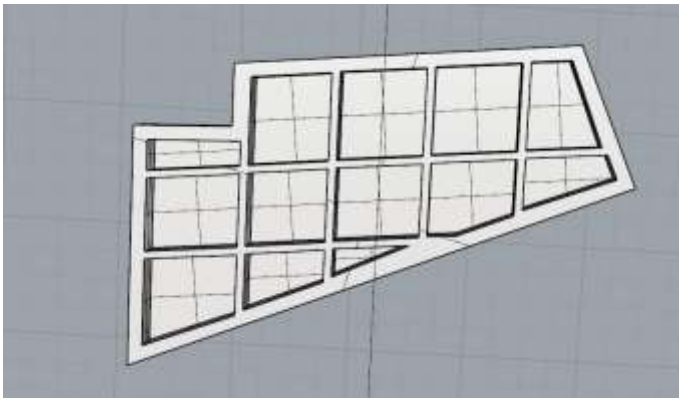




Option 2:

Command: Line

Draw a new line where you want to split the model

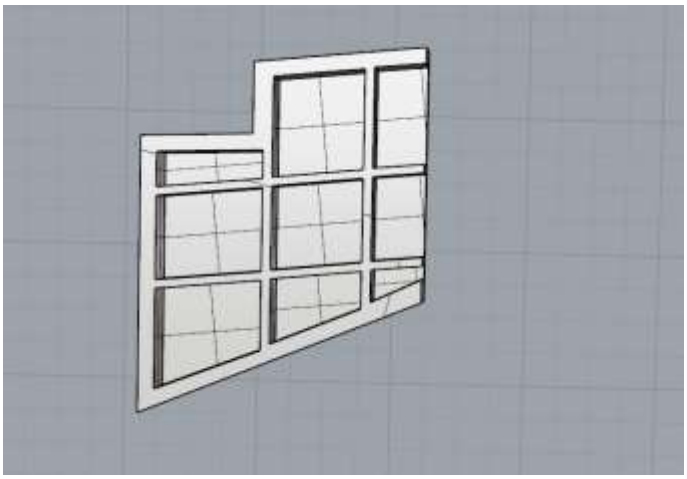


Command: WireCut

Cut the model into two pieces just like Option 1

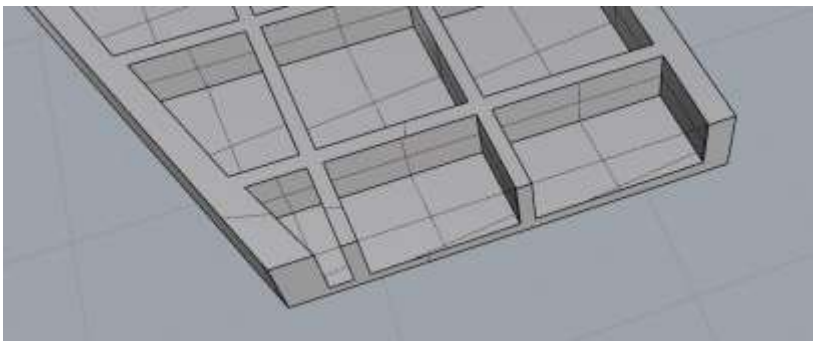
Command: Hide

Hide one of the new pieces



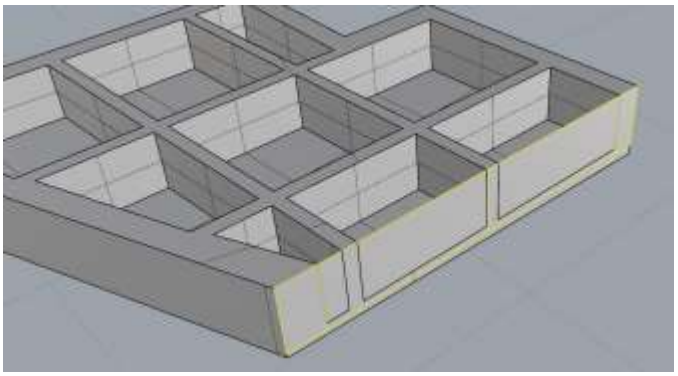
Command: Connect

Connect the two edge lines to form one line across the gap



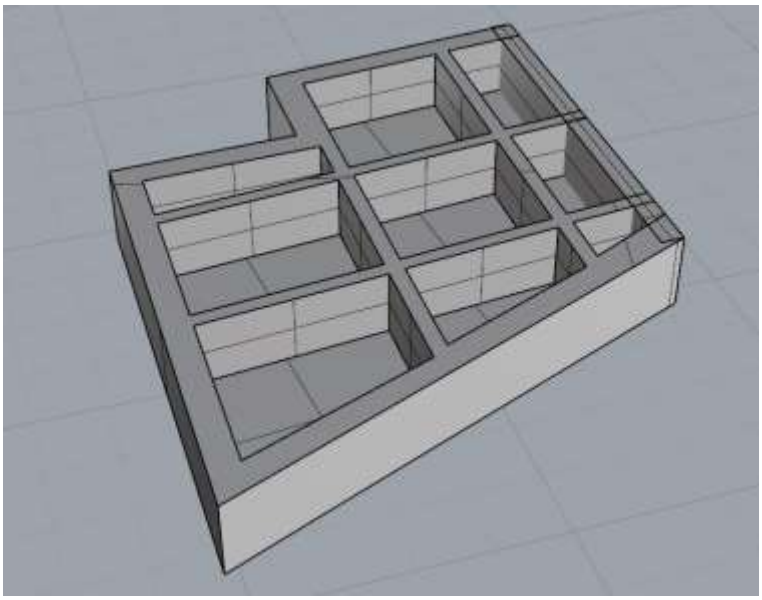
Command: ExtrudeCrv

Extrude the line down into the model

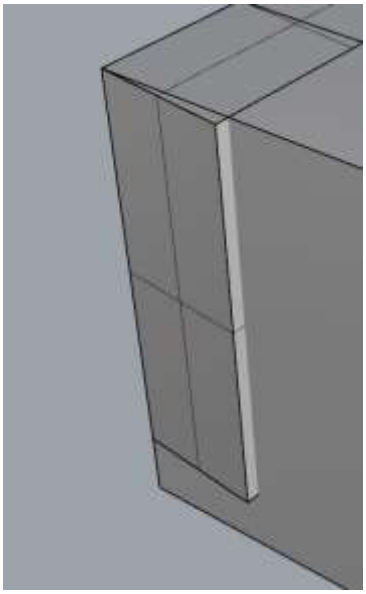


Command: ExtrudeSrf

Extrude the new surface

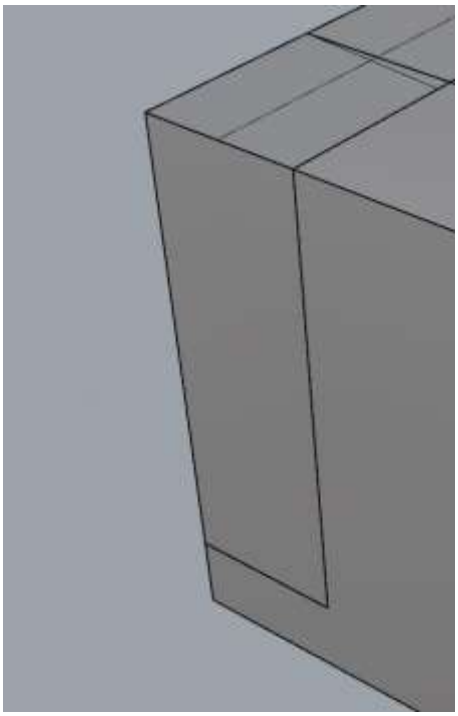


There may be some exposed material that needs to be trimmed



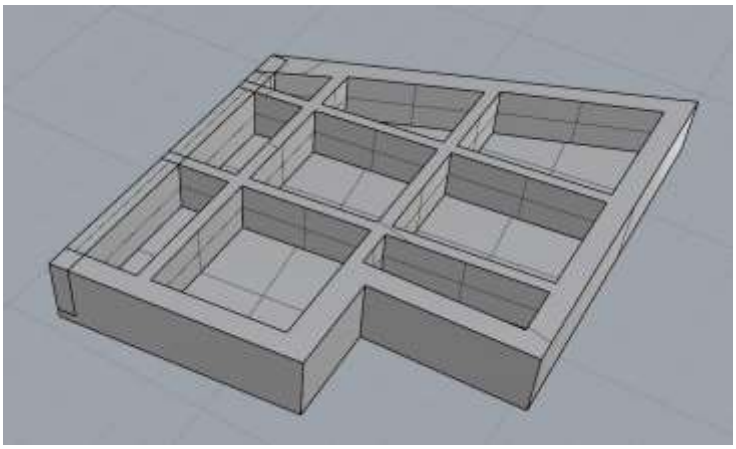
Command: Trim

Trim the excess material



Command: BooleanUnion

Union the extruded surface to the piece



Appendix F. 3D Printer Comparison

Type	Material Cost	Failure Multiplier	Total Cost	Print Time	Post Print Time	Total Time	Success Rate	Quality
Formlabs	.026*150+1.5	2	$10.80	3hrs	20min + day to cure	3.33hrs+cure time	Under 50%	High
Makerbot	.026*50	2	$2.60	3hrs	5hrs	3.083hrs	About 50%	Med-low
Makexyz	13	1	$13	N/A	N/A	week to ship	Ships Correct	Med-high

Appendix G. FormLabs Printer Guide

This guide will discuss the issues found in using the Formlabs 3D printer and the methods used to attempt to fix the issues. It will also describe the correct steps for after a print has finished.

Issues:

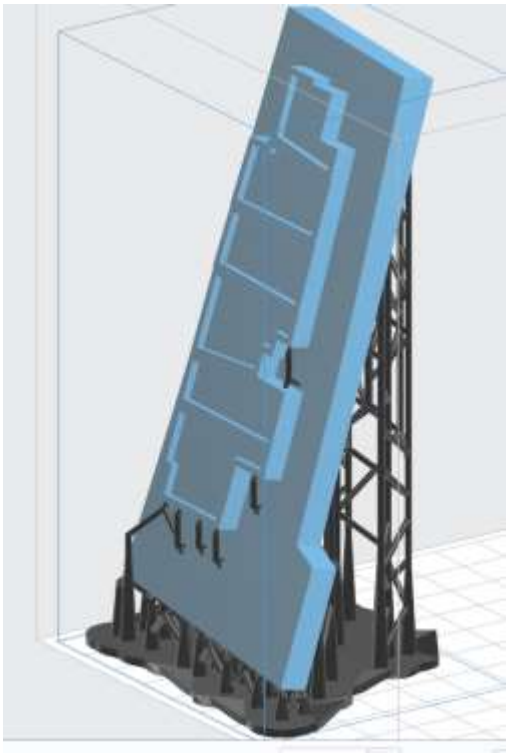
When printing the buildings for the Historic Village, the success rate was incredibly low, around 30%. After studying the failed prints, four main causes were found. The first cause of failure was that digital model was put over a damaged part of the tray in Preform. The image below shows a tray with a damaged section.

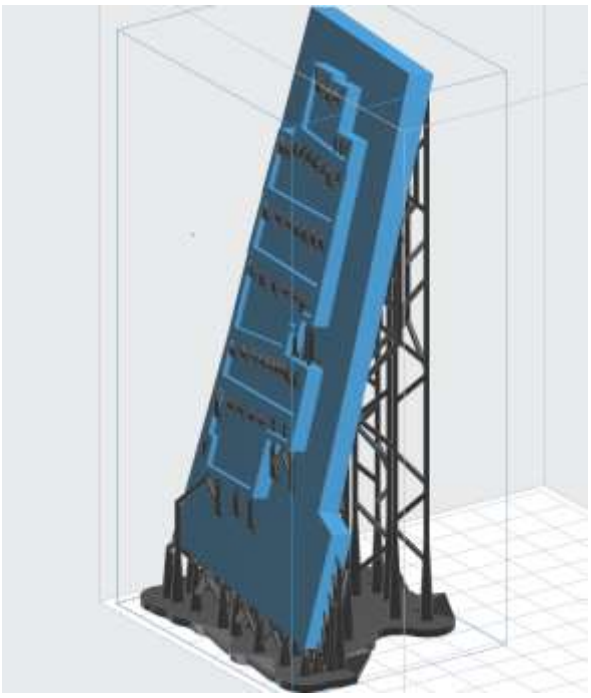
The cloudy part in the middle of the tray is the damaged section. The trays cloud over time from repeated printing in the same area. A failed print also causes significantly more damage to the tray. When a print fails, resin sticks to the bottom of the tray. That already hardened resin is hit repeatedly with the laser, damaging the tray more than it usually would be damaged. It is important to check the tray after each print to see if any new damaged areas have appeared. Printing over a clouded area greatly reduces the probability of getting a successful print. Damage to the tray can also occur from removing excess print residue from the tray. This residue sticks to the bottom of the tray and must be carefully removed. If this is done incorrectly, the pieces of the bottom of the tray, which is made of silicon, can be torn off the tray. When this happens, that portion of the tray can no longer be used again. Proper removal of residue will be discussed in the section describing steps for after a print has finished.

The second cause of failure was that the models were too large. At first we tried prints that would take around 4 to 5 hours to complete. The print would inevitably fail

about halfway through the printing process. The solution to this was to keep the models small enough that the print time was under 2.5 hours.

The third reason prints were failing was due to the lack of building support from the automatically generated support material. Because they stick out of the model at sharp angles, they require extra support to prevent sagging and eventual failure.



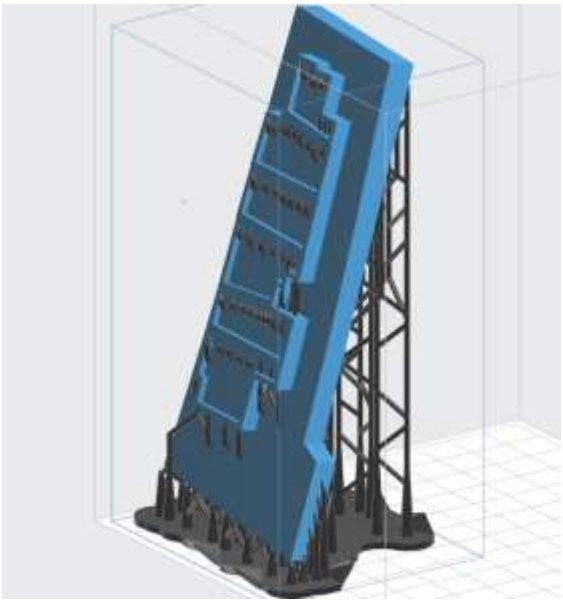


The model on the left is under-supported and will fail. The model on the left has more supports than it might need, but they are easy to remove and do not use up much resin. Once we started adding in extra support materials, our success rate started to increase.

The last main cause of failure was the orientation of the models. After many print failures, it was determined that the building parts of the models were causing air pockets to form around them. Because the buildings stick out from the rest of the model, when the printer moved up a layer, the fluid would sometimes not fill in around the buildings. This caused print failures because with no resin to harden over the model, that part of the layer would be incomplete, causing every layer after it to fail as well. The picture below is a print that failed for this reason:

The print appears to have failed at one small point, which caused the failure to spread over a larger area as the more layers were added.

Solving this issue has proven more challenging than the previous issue. The best method for printing seems to be to have one of the narrower sides of the model connected to the base with a 75 degree angle.



This method seemed to not be a good solution at first. The prints would still fail, but it appears that it was because the models were too large, not because the angle was too sharp. When 45 degrees was tried, both with a narrow side on the base and a wide side on the base, the failure rate was still high due to air pockets forming. Having a

narrow side on the base is ideal because it decreases the area the model takes up on the base. When a wide side is on the base, more area of the tray is damaged, making subsequent prints more likely to fail. It is also riskier because when a print does fail, more area of the tray is damaged because of hardened resin sticking to the base.

Summary:

- Check the tray for damage and do not print on damaged areas
- Keeps the print time to around 2.5 hours
- Add support material to the buildings
- Have a narrow side facing the base with a 75 degree angle

After a print has finished:

Put on a pair of gloves. The resin is not hazardous to touch, but it is very sticky.

Removing the print

After a print has finished, the first step is to remove the model from the base. Wedge a razor blade between the model and the base. Once the model starts to separate from the base, wedge a spackle spatula between the razor and the base, use the spatula to separate the model from the base.

Place the model in the basket and put the basket in the first alcohol base.

Shake for 3 minutes, remove and rest for 5 minutes, then place into the second bath and skate for 3 more minutes. Once the model has been rinsed twice, use the diagonal cutters to remove the support pieces. If there is a large amount of residue in the baths, pour out the alcohol, clean out the baths, and pour in new alcohol.

Now the model needs to cure in sunlight for roughly a day. Place it in a window seal or some other place with good sunlight. Flip the model half-way through to cure both sides. Once it has cured, use razor blade to remove some of the leftover support pieces that the diagonal cutters could not remove. After this is done, lightly sand the model down, especially the edges, so that it will fit correctly with the rest of the pieces.

Maintenance for the Printer

Using the spatula, clean the metal base of the printer. Wipe down the sides of the base with a paper towel. Place back into the printer.

Using the spatula again, lightly brush the tray. Look for any solid pieces of material that need to be removed. If there is any solid pieces of resin, which there most

likely be, use the tweezers to carefully remove the cured resin. If the resin is stuck to the tray, lightly lift the edges of the material, making sure to not rip any silicon from the tray. Dispose of the solid material. Refill the tray with new resin.

If a print failed, strain all of the resin out of the tray into a cup. Failed prints tend to cause a lot of small solid particles that are hard to see. Once the tray has been mostly drained, wipe down the outside edges. If the tray is still usable, put it back into the printer and pour the strained resin back into the tray. If a new tray is needed, throw away the strained resin and pour fresh resin.

Before printing again, use the spatula to brush the surface of the resin. This will get rid of some of the air bubbles on the surface

Make sure to clean the spatula, razor blade, diagonal cutters, and tweezers by spraying with alcohol and drying with a paper towel between each step that they were used for.

Appendix H. Refined Building Survey

A1. Building Identification	
Building Number (Row.Block Building) Ex: 1.01 B	Location (Insert GIS map with unit highlighted)
"Street/Row" Name	
E911 Address	
Location in Historic District? National Register District? Y or N Tribal Historic District? Y or N	

A2. Survey Information	
Date of initial survey	
Primary Surveyor Name: Group Affiliation:	
Inclusion in Previous Surveys	

A3. Massing / Style	
Number of stories 1 or 2	Exterior detail (Insert elevation photos from all sides)
Additions? Y or N Describe, location:	

Similar to typical buildings in village? Y or N	
Style: _____ Pueblo Style _____ Territorial Style _____ Other	

A4. Site Details	
Vegetation Present:	Does wind driven earth build up at the base? Y or N
Branches touching structure? Y or N	Are neighboring buildings a threat to this unit? Y or N
Does the slope of the ground allow proper drainage? Y or N	Is there evidence of ponding in or around the structure? Y or N

A4. Exterior Construction	
Wall Construction _____ adobe _____ CMU _____ frame _____ wood _____ manufactured home _____ mobile home _____ other	**Wall Finish** _____ mud plaster _____ cement stucco _____ other _____ none
Windows ___ traditional ___ Good ___ modern	**Roof** **Style** _____ flat _____ sloped, shed

___ wood ___ aluminum ___ vinyl ___ varies ___ insulated ___ Fair ___ Poor	____ sloped, hipped ____ sloped, gable **Parapets** Y or N **Material** ___ earthen ___ composition: rolled bituminous ___ synthetic rubber ___ metal ___ unknown ___ none **Drainage** ___ canales: wood ___ canales: other ___ gutter and downspout ___ none
Foundation ____ n/a ____ at grade ____ not visible ____ raised	**Vigas** ____ traditional vigas exposed at exteriors ____ vigas plastered over ____ no evidence of vigas
Chimneys ___ Adobe masonry ___ Brick masonry	**Porches** **Type:** ___ traditional ___ modern **Location:** ___ north ___ east ___ south ___ west
Vents ___ present in bathrooms ___ visible heater flues ___ visible plumbing vents	**Doors** ___ traditional ___ modern ___ wood ___ metal ___ glazed ___ security/storm door ___ Good ___ Fair ___ Poor
Contraped Present Y or N	

A5. Exterior Physical Condition	
~~Overall Evaluation~~ ____ ~~Good~~ ____ ~~Fair~~ ____ ~~Poor~~ ____ ~~Severe~~	
Roof Evaluation ____ Good ____ Fair ____ Poor ____ Severe	
Wall Evaluation ____ Good ____ Fair ____ Poor ____ Severe	
Foundation Evaluation ____ Good ____ Fair ____ Poor ____ Severe	
Are there additional structural concerns?	
~~Is the building endangered?~~	

B1. Building Use	
Private ___ primary residence ___ part-time residence ___ uninhabited residence ___ storage ___ kitchen ___ visible plumbing vents	Tribal (This info is just for location) **Not to be shared with outside entities** ___ uninhabited residence ___ storage ___ kitchen ___ visible plumbing vents

Building Age:	

B2. Resident Information			
Resident Contact		Phone # Mailing Address	
Participation in 2014 Tribal Census? Y or N			
	Name	Age	Gender
Head of Household			
~~Number of Residents and Family Sizes~~			
	~~Family 1~~	~~Family 2~~	~~Family 3~~
~~# of Great-grandparents~~			
~~# of Grandparents~~			
~~# of Parents~~			
~~# of Children~~			
Ages of Residents			
	Family 1	Family 2	Family 3
# of Seniors (55+)			
# of Adults (18-54)			
# of Youth (6-17)			
# of Young Children (0-5)			
Total Number of Occupants:			
Multiple Families? Y or N			

Number of Disabled Residents:
Number of Residents with Respiratory Diseases:

B3. Interior Construction/Physical Condition	
Ceiling Construction Type: Evaluation ____ Good ____ Fair ____ Poor ____ Severe	Floor Construction Type: Evaluation ____ Good ____ Fair ____ Poor ____ Severe
Interior Wall Condition Evaluation ____ Good ____ Fair ____ Poor ____ Severe	Staircase (If 2 story home): Evaluation ____ Good ____ Fair ____ Poor ____ Severe

B4. Dwelling Configuration / Quality	
Number of bedrooms	Number of bathrooms
Number of exits/doorways	Heat Source ___ traditional fireplace ___ wood stove ___ gas stove ___ space heater ___ other: ___ none
~~Working restroom? Y or N~~ Working bathroom fixtures: Flush toilet in enclosed room Y or N	~~Working kitchen? Y or N~~ Working kitchen appliances: Refrigerator Y or N

Fixed wash basin or lavatory Y or N Tub or shower Y or N	Stove or range with oven Y or N Sink Y or N
Working Electricity? Y or N	~~Working heat? Y or N~~

B5. Hazards
Is Mold believed to be present? Y or N Level of Mold (Circle One) Small Isolated Areas: < 10 sf Mid-Size Isolated Areas: 10-30 sf Large Isolated Areas: 30-100 sf Extensive Contamination: > 100 sf
Are there signs of infestation? Y or N Location of infestation:
Is there lead paint present? Y or N Location of lead paint:

B6. Housing Authority Assistance
2012 Roof Replacement
2013 Roof Replacement
2014 ICDBG
Other assistance
Have you applied for assistance in the past?

Maintenance History						
	Pre-2000	2000-2002	2003-2005	2006-2008	2009-2011	2012-2014
Roof						
Ceiling						
Ext. Walls						
Int. Walls						
Floors						
Mechanical						
Electrical						
Plumbing						
Mold						

Appendix I. Visual Assessment Guide

Roof

GOOD	
FAIR	
POOR	
SEVERE	

Wall

GOOD	
FAIR	
POOR	
SEVERE	

Stucco Structural Flaws

CRACKING	
SPALLING	
DELAMINATION	

Metal Windows

GOOD	
FAIR	

Vinyl Windows

GOOD	
FAIR	
POOR	

Wooden Windows

GOOD	
FAIR	
POOR	

Wood Doors

GOOD	
FAIR	
POOR	

Other key features

CONTRAPARED	
BUTTRESS	
VIGAS	

Appendix J. Priority Points (Ranked in Order) for Structural and Building Use Criteria

Building	Unit	Total Points
7.03	C	29
13.09	A	27
3.01	F	26
5.01	C	26
6.02	F	26
17.06	A	26
1.03	C	25
2.01	A	25
3.01	M	25
5.04	A	25
7.02	C	25
1.03	D	24
1.04	A	24
2.01	D	24
3.02	A	24
4.02	B	24
7.01	A	24
9.03	B	24
10.1	A	24
16.03	A	24
3.01	G	23
3.01	C	23
4.02	C	23
4.07	E	23
5.01	A	23
5.06	C	23
6.01	A	23

6.08	E	23
11.05	A	23
15.06	C	23
18.09	A	23
1.01	B	22
3.04	B	22
4.04	A	22
5.05	A	22
11.06	A	22
13.04	B	22
15.04	A	22
1.03	B	21
4.02	G	21
4.05	B	21
5.02	D	21
6.04	E	21
6.08	F	21
6.08	H	21
6.09	A	21
7.02	E	21
7.02	G	21
8.03	B	21
8.06	B	21
9.02	A	21
10.08	A	21
13.04	A	21
17.02	A	21
1.01	D	20
1.04	H	20
4.02	D	20
4.07	C	20
5.01	B	20
6.02	G	20

6.1	C	20
7.04	A	20
8.01	B	20
8.02	C	20
8.06	A	20
14.01	D	20
18.07	A	20
2.02	G	19
3.01	K	19
4.03	A	19
5.01	D	19
5.04	D	19
18.07	B	19
1.04	C	18
4.03	B	18
5.03	A	18
5.04	C	18
7.02	I	18
10.09	A	18
10.11	A	18
13.07	A	18
14.01	A	18
18.06	A	18
3.06	D	17
4.07	A	17
5.02	B	17
5.02	F	17
5.04	B	17
9.01	B	17
1.04	D	16
2.03	B	16
3.01	D	16
4.03	C	16

5.01	F	16
14.02	B	16
2.02	H	15
3.01	B	15
4.06	C	15
4.07	D	15
6.04	D	15
6.04	C	15
9.01	A	15
2.02	C	13
3.06	A	13
12.04	A	13
8.03	C	11

Appendix K. Priority Points (Ranked in Order) for Structural and Building Use Criteria; Residential Density Weighted x2

Building	Unit	Points
7.03	C	33
13.09	A	31
3.01	F	30
5.01	C	30
6.02	F	29
17.06	A	29
2.01	A	29
3.01	M	29
5.04	A	29
10.1	A	29
7.02	C	28
1.04	A	28
3.02	A	28
16.03	A	28
1.03	C	27
1.03	D	27
9.03	B	27
3.01	G	27
5.01	A	27
6.08	E	27
2.01	D	26
4.02	B	26
3.01	C	26

5.06	C	26
6.01	A	26
15.06	C	26
18.09	A	26
1.01	B	26
5.05	A	26
11.06	A	26
13.04	B	26
7.01	A	25
4.02	C	25
4.07	E	25
11.05	A	25
4.04	A	25
15.04	A	25
4.05	B	25
5.02	D	25
9.02	A	25
3.04	B	24
4.02	G	24
6.08	F	24
7.02	E	24
7.02	G	24
8.06	B	24
13.04	A	24
17.02	A	24
4.07	C	24
8.01	B	24

1.03	B	23
6.09	A	23
1.04	H	23
5.01	B	23
6.02	G	23
6.1	C	23
8.02	C	23
14.01	D	23
18.07	A	23
2.02	G	23
5.04	D	23
6.04	E	22
6.08	H	22
8.03	B	22
10.08	A	22
10.09	A	22
1.01	D	21
4.02	D	21
7.04	A	21
8.06	A	21
4.03	A	21
5.01	D	21
18.07	B	21
5.03	A	21
7.02	I	21
3.01	K	20
1.04	C	20

4.03	B	20
5.04	C	20
10.11	A	20
13.07	A	20
18.06	A	20
3.06	D	20
5.02	F	20
9.01	B	20
14.01	A	19
5.02	B	19
1.04	D	19
4.03	C	19
14.02	B	19
4.07	A	18
5.04	B	18
2.03	B	18
6.04	D	18
3.01	D	17
5.01	F	17
4.07	D	17
9.01	A	17
2.02	H	16
3.01	B	16
4.06	C	16
6.04	C	16
12.04	A	15
2.02	C	14

3.06	A	14
8.03	C	12

Appendix L. Priority Points (Ranked in Order) for Structural Criteria Only

Building	Unit	Structural Points
4.02	B	15
7.03	C	15
13.09	A	15
3.01	F	14
4.07	E	14
5.01	C	14
6.02	F	14
7.02	C	14
1.01	D	13
1.03	C	13
2.01	A	13
4.02	C	13
4.02	D	13
4.03	A	13
5.01	A	13
5.01	B	13
5.01	D	13
5.04	A	13
6.04	E	13
7.01	A	13
8.06	A	13
9.03	B	13
11.05	A	13
15.06	C	13
16.03	A	13
17.06	A	13

2.01	D	12
7.04	A	12
1.03	B	11
1.03	D	11
1.04	A	11
3.01	G	11
5.06	C	11
6.08	E	11
6.08	H	11
8.03	B	11
8.06	B	11
18.07	B	11
3.01	M	10
3.01	C	10
3.02	A	10
3.04	B	10
4.03	B	10
4.04	A	10
4.07	C	10
5.02	F	10
5.04	C	10
5.04	B	10
6.01	A	10
6.04	C	10
6.08	F	10
6.09	A	10
7.02	E	10
7.02	G	10
8.02	C	10
10.08	A	10
10.1	A	10
11.06	A	10
13.04	A	10

14.01	D	10
14.01	A	10
18.06	A	10
18.07	A	10
18.09	A	10
3.01	K	9
5.02	D	9
5.02	B	9
6.02	G	9
13.07	A	9
1.01	B	8
2.02	C	8
3.06	A	8
5.01	F	8
5.04	D	8
13.04	B	8
15.04	A	8
1.04	H	7
1.04	C	7
1.04	D	7
2.02	G	7
2.02	H	7
2.03	B	7
3.01	B	7
3.06	D	7
4.02	G	7
4.03	C	7
4.05	B	7
4.06	C	7
4.07	D	7
4.07	A	7
5.05	A	7
6.1	C	7

7.02	I	7
8.01	B	7
9.01	B	7
9.01	A	7
9.02	A	7
10.09	A	7
10.11	A	7
12.04	A	7
17.02	A	7
3.01	D	6
5.03	A	6
6.04	D	6
8.03	C	6
14.02	B	6

Appendix M. Cost Estimates

Building	Unit	Issue Level	Direct Cost per SF	Area (SF)	Direct Cost	Overhead & Profit (10%)	General Conditions (10%)	Contingency (30%)	Two-Story Multiplier	Total Estimated Cost
1.01	C	Minor	$42.30	1062	$44,922.60	$4,492.26	$4,492.26	$13,476.78		$67,383.90
1.01	B	Moderate	$54.47	2031	$110,628.57	$11,062.86	$11,062.86	$33,188.57		$165,942.86
1.01	D	Major	$75.46	3229	$243,660.34	$24,366.03	$24,366.03	$73,098.10		$365,490.51
1.02	A	Major	$75.46	628	$47,388.88	$4,738.89	$4,738.89	$14,216.66		$71,083.32
1.03	B	Moderate	$54.47	1867	$101,695.49	$10,169.55	$10,169.55	$30,508.65		$152,543.24
1.03	D	Moderate	$54.47	2000	$108,940.00	$10,894.00	$10,894.00	$32,682.00		$163,410.00
1.03	C	Major	$75.46	2992	$225,776.32	$22,577.63	$22,577.63	$67,732.90		$338,664.48
1.04	D	Minor	$42.30	1411	$59,685.30	$5,968.53	$5,968.53	$17,905.59	2	$179,055.90
1.04	H	Minor	$42.30	1957	$82,781.10	$8,278.11	$8,278.11	$24,834.33		$124,171.65
1.04	C	Minor	$42.30	2622	$110,910.60	$11,091.06	$11,091.06	$33,273.18		$166,365.90
1.04	A	Moderate	$54.47	2238	$121,903.86	$12,190.39	$12,190.39	$36,571.16		$182,855.79
2.01	A	Major	$75.46	1335	$100,739.10	$10,073.91	$10,073.91	$30,221.73		$151,108.65
2.01	D	Moderate	$54.47	2945	$160,414.15	$16,041.42	$16,041.42	$48,124.25		$240,621.23
2.02	G	Minor	$42.30	751	$31,767.30	$3,176.73	$3,176.73	$9,530.19		$47,650.95
2.02	C	Moderate	$54.47	1900	$103,493.00	$10,349.30	$10,349.30	$31,047.90	2	$310,479.00
2.02	H	Minor	$42.30	5835	$246,820.50	$24,682.05	$24,682.05	$74,046.15		$370,230.75
2.03	B	Minor	$42.30	2163	$91,494.90	$9,149.49	$9,149.49	$27,448.47		$137,242.35
2.03	E	Moderate	$54.47	1379	$75,114.13	$7,511.41	$7,511.41	$22,534.24		$112,671.20
3.01	B	Minor	$42.30	1084	$45,853.20	$4,585.32	$4,585.32	$13,755.96		$68,779.80
3.01	C	Moderate	$54.47	1019	$55,504.93	$5,550.49	$5,550.49	$16,651.48		$83,257.40
3.01	M	Moderate	$54.47	1037	$56,485.39	$5,648.54	$5,648.54	$16,945.62		$84,728.09

3.01	D	Minor	$42.30	1691	$71,529.30	$7,152.93	$7,152.93	$21,458.79		$107,293.95
3.01	K	Moderate	$54.47	1416	$77,129.52	$7,712.95	$7,712.95	$23,138.86		$115,694.28
3.01	G	Moderate	$54.47	2114	$115,149.58	$11,514.96	$11,514.96	$34,544.87		$172,724.37
3.01	F	Major	$75.46	1780	$134,318.80	$13,431.88	$13,431.88	$40,295.64		$201,478.20
3.02	A	Moderate	$54.47	1487	$80,996.89	$8,099.69	$8,099.69	$24,299.07		$121,495.34
3.04	B	Moderate	$54.47	2013	$109,648.11	$10,964.81	$10,964.81	$32,894.43		$164,472.17
3.06	D	Minor	$42.30	2218	$93,821.40	$9,382.14	$9,382.14	$28,146.42		$140,732.10
3.06	A	Moderate	$54.47	1931	$105,181.57	$10,518.16	$10,518.16	$31,554.47		$157,772.36
4.02	G	Minor	$42.30	2311	$97,755.30	$9,775.53	$9,775.53	$29,326.59	2	$293,265.90
4.02	C	Major	$75.46	1797	$135,601.62	$13,560.16	$13,560.16	$40,680.49		$203,402.43
4.02	B	Major	$75.46	1833	$138,318.18	$13,831.82	$13,831.82	$41,495.45		$207,477.27
4.02	D	Major	$75.46	1926	$145,335.96	$14,533.60	$14,533.60	$43,600.79		$218,003.94
4.02	A	Major	$75.46	1217	$91,834.82	$9,183.48	$9,183.48	$27,550.45		$137,752.23
4.03	C	Minor	$42.30	1460	$61,758.00	$6,175.80	$6,175.80	$18,527.40		$92,637.00
4.03	B	Moderate	$54.47	2668	$145,325.96	$14,532.60	$14,532.60	$43,597.79	2	$435,977.88
4.03	A	Major	$75.46	2137	$161,258.02	$16,125.80	$16,125.80	$48,377.41		$241,887.03
4.04	A	Moderate	$54.47	1894	$103,166.18	$10,316.62	$10,316.62	$30,949.85		$154,749.27
4.05	B	Minor	$42.30	779	$32,951.70	$3,295.17	$3,295.17	$9,885.51	2	$98,855.10
4.06	C	Minor	$42.30	1145	$48,433.50	$4,843.35	$4,843.35	$14,530.05		$72,650.25
4.07	D	Minor	$42.30	925	$39,127.50	$3,912.75	$3,912.75	$11,738.25		$58,691.25
4.07	A	Minor	$42.30	1930	$81,639.00	$8,163.90	$8,163.90	$24,491.70		$122,458.50
4.07	C	Moderate	$54.47	1725	$93,960.75	$9,396.08	$9,396.08	$28,188.23		$140,941.13
4.07	E	Major	$75.46	2596	$195,894.16	$19,589.42	$19,589.42	$58,768.25		$293,841.24
5.01	F	Moderate	$54.47	1482	$80,724.54	$8,072.45	$8,072.45	$24,217.36	2	$242,173.62
5.01	C	Major	$75.46	1287	$97,117.02	$9,711.70	$9,711.70	$29,135.11	2	$291,351.06
5.01	D	Major	$75.46	1310	$98,852.60	$9,885.26	$9,885.26	$29,655.78		$148,278.90
5.01	A	Major	$75.46	1464	$110,473.44	$11,047.34	$11,047.34	$33,142.03		$165,710.16

5.01	B	Major	$75.46	1649	$124,433.54	$12,443.35	$12,443.35	$37,330.06		$186,650.31
5.02	D	Moderate	$54.47	1700	$92,599.00	$9,259.90	$9,259.90	$27,779.70	2	$277,797.00
5.02	F	Moderate	$54.47	1701	$92,653.47	$9,265.35	$9,265.35	$27,796.04		$138,980.21
5.02	B	Moderate	$54.47	2141	$116,620.27	$11,662.03	$11,662.03	$34,986.08	2	$349,860.82
5.03	A	Minor	$42.30	1567	$66,284.10	$6,628.41	$6,628.41	$19,885.23		$99,426.15
5.04	B	Moderate	$54.47	935	$50,929.45	$5,092.95	$5,092.95	$15,278.84		$76,394.18
5.04	D	Moderate	$54.47	1047	$57,030.09	$5,703.01	$5,703.01	$17,109.03	2	$171,090.28
5.04	A	Major	$75.46	935	$70,555.10	$7,055.51	$7,055.51	$21,166.53	2	$211,665.30
5.04	C	Moderate	$54.47	1559	$84,918.73	$8,491.87	$8,491.87	$25,475.62	2	$254,756.20
5.05	A	Minor	$42.30	1229	$51,986.70	$5,198.67	$5,198.67	$15,596.01		$77,980.05
5.06	B	Minor	$42.30	1053	$44,541.90	$4,454.19	$4,454.19	$13,362.57		$66,812.85
5.06	C	Moderate	$54.47	2146	$116,892.62	$11,689.26	$11,689.26	$35,067.79		$175,338.93
6.01	A	Moderate	$54.47	2363	$128,712.61	$12,871.26	$12,871.26	$38,613.78	2	$386,137.84
6.02	H	Minor	$42.30	821	$34,711.20	$3,471.12	$3,471.12	$10,413.36		$52,066.80
6.02	B	Moderate	$54.47	1432	$77,990.54	$7,799.05	$7,799.05	$23,397.16		$116,985.82
6.02	G	Moderate	$54.47	2435	$132,634.45	$13,263.45	$13,263.45	$39,790.34		$198,951.68
6.02	F	Major	$75.46	1880	$141,864.80	$14,186.48	$14,186.48	$42,559.44		$212,797.20
6.02	A	Minor	$42.30	1495	$63,238.50	$6,323.85	$6,323.85	$18,971.55		$94,857.75
6.02	B	Moderate	$54.47	1432	$78,001.04	$7,800.10	$7,800.10	$23,400.31		$117,001.56
6.02	C	Moderate	$54.47	1075	$58,555.25	$5,855.53	$5,855.53	$17,566.58		$87,832.88
6.02	E	Minor	$42.30	1149	$48,602.70	$4,860.27	$4,860.27	$14,580.81		$72,904.05
6.04	B	Minor	$42.30	844	$35,717.52	$3,571.75	$3,571.75	$10,715.26		$53,576.28
6.04	D	Minor	$42.30	2177	$92,087.10	$9,208.71	$9,208.71	$27,626.13		$138,130.65
6.04	C	Moderate	$54.47	2008	$109,375.76	$10,937.58	$10,937.58	$32,812.73		$164,063.64
6.04	E	Major	$75.46	1751	$132,130.46	$13,213.05	$13,213.05	$39,639.14		$198,195.69
6.08	G	Minor	$42.30	1173	$49,621.50	$4,962.15	$4,962.15	$14,886.45	2	$148,864.49
6.08	E	Moderate	$54.47	964	$52,509.08	$5,250.91	$5,250.91	$15,752.72		$78,763.62

6.08	F	Moderate	$54.47	1045	$56,921.15	$5,692.12	$5,692.12	$17,076.35		$85,381.73
6.08	H	Moderate	$54.47	1992	$108,504.24	$10,850.42	$10,850.42	$32,551.27		$162,756.36
6.08	A	Moderate	$54.47	2784	$151,665.40	$15,166.54	$15,166.54	$45,499.62		$227,498.10
6.09	A	Moderate	$54.47	578	$31,483.66	$3,148.37	$3,148.37	$9,445.10		$47,225.49
6.1	C	Minor	$42.30	1265	$53,509.50	$5,350.95	$5,350.95	$16,052.85		$80,264.25
6.1	D	Moderate	$54.47	1564	$85,190.04	$8,519.00	$8,519.00	$25,557.01		$127,785.05
7.01	A	Major	$75.46	2475	$186,763.50	$18,676.35	$18,676.35	$56,029.05		$280,145.25
7.02	I	Minor	$42.30	1330	$56,259.00	$5,625.90	$5,625.90	$16,877.70	2	$168,777.00
7.02	A	Moderate	$54.47	1393	$75,876.73	$7,587.67	$7,587.67	$22,763.02		$113,815.09
7.02	E	Moderate	$54.47	1454	$79,199.38	$7,919.94	$7,919.94	$23,759.81		$118,799.07
7.02	D	Moderate	$54.47	1590	$86,603.39	$8,660.34	$8,660.34	$25,981.02		$129,905.08
7.02	G	Moderate	$54.47	1963	$106,924.61	$10,692.46	$10,692.46	$32,077.38		$160,386.92
7.02	C	Major	$75.46	3489	$263,279.94	$26,327.99	$26,327.99	$78,983.98		$394,919.91
7.03	C	Major	$75.46	469	$35,390.74	$3,539.07	$3,539.07	$10,617.22	2	$106,172.22
7.04	A	Moderate	$54.47	1840	$100,224.80	$10,022.48	$10,022.48	$30,067.44		$150,337.20
8.01	B	Minor	$42.30	552	$23,349.60	$2,334.96	$2,334.96	$7,004.88	2	$70,048.80
8.02	C	Moderate	$54.47	2433	$132,525.51	$13,252.55	$13,252.55	$39,757.65		$198,788.27
8.03	C	Minor	$42.30	1442	$60,996.60	$6,099.66	$6,099.66	$18,298.98		$91,494.90
8.03	B	Moderate	$54.47	2202	$119,942.94	$11,994.29	$11,994.29	$35,982.88		$179,914.41
8.06	B	Moderate	$54.47	2241	$122,067.27	$12,206.73	$12,206.73	$36,620.18	2	$366,201.82
8.06	A	Major	$75.46	2861	$215,891.06	$21,589.11	$21,589.11	$64,767.32		$323,836.59
9.01	A	Minor	$42.30	2195	$92,848.50	$9,284.85	$9,284.85	$27,854.55		$139,272.75
9.01	B	Minor	$42.30	3929	$166,196.70	$16,619.67	$16,619.67	$49,859.01		$249,295.05
9.02	A	Minor	$42.30	966	$40,861.80	$4,086.18	$4,086.18	$12,258.54		$61,292.70
9.03	B	Major	$75.46	2609	$196,875.14	$19,687.51	$19,687.51	$59,062.54	2	$590,625.42
9.04	A	Moderate	$54.47	1322	$72,024.47	$7,202.45	$7,202.45	$21,607.34		$108,036.70
10.08	A	Moderate	$54.47	2578	$140,423.66	$14,042.37	$14,042.37	$42,127.10		$210,635.49

10.09	A	Minor	$42.30	2578	$109,049.40	$10,904.94	$10,904.94	$32,714.82		$163,574.10
10.1	A	Moderate	$54.47	1225	$66,725.75	$6,672.58	$6,672.58	$20,017.73		$100,088.63
10.11	A	Minor	$42.30	2721	$115,098.30	$11,509.83	$11,509.83	$34,529.49		$172,647.45
10.13	A	Moderate	$54.47	2453	$133,631.69	$13,363.17	$13,363.17	$40,089.51		$200,447.54
11.05	A	Major	$75.46	3084	$232,718.64	$23,271.86	$23,271.86	$69,815.59		$349,077.96
11.06	A	Moderate	$54.47	2174	$118,417.78	$11,841.78	$11,841.78	$35,525.33	2	$355,253.34
12.02	A	Moderate	$54.47	2454	$133,675.82	$13,367.58	$13,367.58	$40,102.75		$200,513.73
12.04	A	Minor	$42.30	1230	$52,029.00	$5,202.90	$5,202.90	$15,608.70		$78,043.50
13.04	B	Moderate	$54.47	909	$49,513.23	$4,951.32	$4,951.32	$14,853.97	2	$148,539.70
13.04	A	Moderate	$54.47	3407	$185,579.29	$18,557.93	$18,557.93	$55,673.79		$278,368.94
13.05	D	Moderate	$54.47	1698	$92,498.81	$9,249.88	$9,249.88	$27,749.64		$138,748.21
13.06	A	Moderate	$54.47	1795	$97,776.47	$9,777.65	$9,777.65	$29,332.94		$146,664.70
13.07	A	Moderate	$54.47	1149	$62,586.03	$6,258.60	$6,258.60	$18,775.81		$93,879.05
13.09	A	Major	$75.46	1244	$93,872.24	$9,387.22	$9,387.22	$28,161.67		$140,808.36
14.01	A	Moderate	$54.47	1957	$106,597.79	$10,659.78	$10,659.78	$31,979.34		$159,896.69
14.01	D	Moderate	$54.47	3376	$183,890.72	$18,389.07	$18,389.07	$55,167.22		$275,836.08
14.02	B	Minor	$42.30	1954	$82,654.20	$8,265.42	$8,265.42	$24,796.26		$123,981.30
14.03	A	Minor	$42.30	3353	$141,836.93	$14,183.69	$14,183.69	$42,551.08	2	$425,510.79
15.04	A	Moderate	$54.47	2234	$121,685.98	$12,168.60	$12,168.60	$36,505.79	2	$365,057.94
15.06	C	Major	$75.46	2147	$162,012.62	$16,201.26	$16,201.26	$48,603.79		$243,018.93
16.03	A	Major	$75.46	290	$21,883.40	$2,188.34	$2,188.34	$6,565.02		$32,825.10
17.02	A	Minor	$42.30	2236	$94,582.80	$9,458.28	$9,458.28	$28,374.84		$141,874.20
17.02	B	Moderate	$54.47	2998	$163,301.43	$16,330.14	$16,330.14	$48,990.43		$244,952.14
17.02	C	Major	$75.46	3333	$251,477.09	$25,147.71	$25,147.71	$75,443.13		$377,215.63
17.03	A	Minor	$42.30	1901	$80,430.70	$8,043.07	$8,043.07	$24,129.21		$120,646.05
17.06	A	Major	$75.46	3586	$270,599.56	$27,059.96	$27,059.96	$81,179.87	2	$811,798.68
17.07	A	Minor	$42.30	2254	$95,353.51	$9,535.35	$9,535.35	$28,606.05		$143,030.27

18.02	A	Minor	$42.30	2900	$122,664.77	$12,266.48	$12,266.48	$36,799.43		$183,997.15
18.06	A	Moderate	$54.47	3852	$209,818.44	$20,981.84	$20,981.84	$62,945.53		$314,727.66
18.07	B	Moderate	$54.47	1775	$96,684.25	$9,668.43	$9,668.43	$29,005.28	2	$290,052.76
18.07	A	Moderate	$54.47	2770	$150,881.90	$15,088.19	$15,088.19	$45,264.57		$226,322.85
18.09	A	Moderate	$54.47	1980	$107,850.60	$10,785.06	$10,785.06	$32,355.18		$161,775.90