



Final Report

Residential Fire Sprinkler Cost Benefit Analysis
for
Clark County (NV) Fire Department
June 2023

Author:

**Sanford D. Mangold
HBM Associates, LLC**



Final Report

Executive Summary:

This is a study commissioned by the Clark County Fire Department, which is written in parallel with a similar study that this author produced in July 2017 for the City of Las Vegas. As was the case then and is the case now, this study provides a dispassionate and objective cost benefit analysis of residential fire suppression (sprinkler) systems, which could be mandated in all new home construction up to 5,000 square feet of livable space. This study is in direct response of Nevada Revised Statute (NRS) 278.586, which specifies that any governing body considering such a mandate must perform a cost benefit analysis and hold a public hearing on the results of that analysis prior to enacting legislation requiring residential fire suppression systems in all new home construction.

The following pages detail the HBM Associates study, which compares and contrasts the study results with those provided by;

- The National Institute of Standards and Technology (NIST): Benefit-Cost Analysis of Residential Fire Sprinkler Systems (NISTIR-7451), September 2007.
- Applied Analysis: Benefit-Cost Analysis of Residential Fire Suppression Systems – A Review and Analysis in Unincorporated Clark County, March 2015.
- University of Nevada Las Vegas (UNLV), Residential Fire Sprinkler Cost Benefit Analysis for City of Las Vegas (NV) Fire and Rescue, July 2017.

HBM Associates performed an independent and detailed study over the course of two (2) months through a comprehensive review of previous reports, studies, and associated statistics regarding the effectiveness of residential fire sprinkler systems. All of these sources were used to create this up-to-date and structurally sound report. Through this effort, this study reaffirms that there continues to be a definite cost benefit to both homeowners and home builders by installing fire suppression systems in all new residential homes up to 5,000 square feet of livable space throughout all of Clark County, Nevada. The costing data (as articulated in this report and detailed in the appendices) demonstrates that new homes built with fire sprinkler systems (installed during the home's construction phase) essentially "pay back" the homeowner the expense of fire sprinkler installation within the first twelve (12) months after the home is purchased.

Moreover, as was the case with the aforementioned UNLV study, this report also clearly shows that **safety** should become the primary reason for mandating installation of residential fire sprinkler systems. Nevertheless, this study satisfies the cost-benefit requirements stated in NRS 278.586. Additionally, this study addressed NRS 237.080, which focused on the need to seek input from any entity, company, or trade organization potentially impacted by the adoption of any proposed rule (e.g., the requirement to install residential fire sprinkler systems in all new residential construction). In both cases, this study determined that Clark County would be in complete compliance with all appropriate Nevada statutes. Finally, this study also investigated the ramifications of NRS 202.580, which addresses the criminal implications of installing a faulty fire sprinkler system or damaging a functioning system.



Final Report

About the Author:

Colonel Sanford D. Mangold (USAF, Retired) is a highly decorated military officer, who spent nearly thirty (30) years in service to our Nation. He is a Distinguished Military Graduate from the Air Force Reserve Officers Training Corps (AFROTC) at the University of Florida, where he graduated with Honors while earning a Bachelor of Science Degree (Mathematics). Colonel Mangold subsequently attended and graduated from the Air Command & Staff College; the Air Force Institute of Technology's School of Engineering; and the Naval War College's College of Naval Warfare. He holds two Masters' Degrees.

Colonel Mangold has had a long and distinguished military career serving at nineteen (19) duty locations around the United States and overseas. He served as a Space Shuttle Flight Controller working in Mission Control at the NASA/Johnson Space Center; worked as an Orbital Analyst in Cheyenne Mountain (Colorado); was an Aide to a Lieutenant General; Commanded Space Command's Outstanding Surveillance Squadron, while stationed in the Middle East; was selected as a Joint Staff and National Security Council Planner, while stationed at the Pentagon; and served as an Intern on the National Security Council. He has been awarded the Legion of Merit; the Joint Service Meritorious Service Medal; four (4) USAF Meritorious Service Medals; and numerous other civilian & military awards to include the FBI National Citizens Academy Alumni Association's Meritorious Service Medal.

Colonel Mangold has taught college at the Undergraduate and Graduate levels for the past thirty-four (34) years at six (6) different colleges & universities. He has taught in the University of Nevada Las Vegas' Emergency and Crisis Management Program for ten (10) years. During that time, he has developed a strong understanding of the unique issues associated with Clark County and its diverse cultural & business composition. In 2017, he was the principal author on UNLV's "Residential Fire Sprinkler Cost Benefit Analysis for City of Las Vegas (NV) Fire and Rescue." This report was given unanimous approval by the Las Vegas City Council and led to the establishment of a City Ordinance requiring residential fire sprinkler systems in all new single-family construction. Most recently, he authored the two-volume UNLV After-Action Report following the COVID-19 pandemic.

Colonel Mangold was certified as a Volunteer Firefighter (Seabrook Fire Department, Texas) and Emergency Medical Technical (EMT) with the Clearlake (TX) Emergency Medical Corps. He graduated from Firefighter Training (College Station, TX) and from the Santa Fe (TX) Community College EMT Program. He survived a "flashover," while fighting an apartment fire and participated in numerous other fire and emergency medical rescue events.

While in college and prior to entry onto active duty, Colonel Mangold supplemented his AFROTC Scholarship by working as a roofer, framing carpenter, and as labor foreman on a concrete forms crew (building parking garages).



Final Report

Purpose:

The purpose of this study is to present an objective analysis regarding the possible installation of residential fire sprinkler systems in all new single-family home constructions in Clark County, Nevada. The statement of work that initiated this study (Attachment 1) directed the study, analysis, and documentation the perspectives presented in three (3) studies prepared on this subject by knowledgeable National, state, and business organizations:

- The National Institute of Standards and Technology (NIST): Benefit-Cost Analysis of Residential Fire Sprinkler Systems (NISTIR-7451), September 2007.
- Applied Analysis: Benefit-Cost Analysis of Residential Fire Suppression Systems – A Review and Analysis in Unincorporated Clark County, March 2015.
- University of Nevada Las Vegas (UNLV), Residential Fire Sprinkler Cost Benefit Analysis for City of Las Vegas (NV) Fire and Rescue, July 2017.

Background:

Clark County, Nevada, through the Clark County Fire Department, commissioned a cost-benefit analysis to determine the affordability of residential fire sprinklers in single family dwellings with usable living space equaling 5,000 square feet or less. This analysis is to determine the costs associated with a county-wide mandate, as well as the benefits the homeowner and the county gained from residential fire sprinklers. This cost-benefit analysis is also required to satisfy Nevada Revised Statute 278.586 enacted during the 2015 Nevada legislative session through Senate Bill 477 (Attachment 1). Embedded in the Senate language is a mandate requiring a cost-benefit analysis be performed to demonstrate that the installation of a residential fire suppression system in a new home would be:

- to the benefit of the owners of the residential dwelling units to which the requirement would be applicable and that such benefit exceeds the costs related to the installation of automatic fire sprinkler systems in such residential dwelling units. (Reference: Nevada Senate Bill 477)

Further, Clark County may elect to issue a mandate requiring fire suppression systems in new residential homes with livable area of 5,000 square feet or less, if:

- the unique characteristics or the location of the residential dwelling unit, when compared to residential dwelling units of comparable size or location within the jurisdiction of the governing body, would cause an unreasonable delay in firefighter response time. (Reference: Nevada Senate Bill 477)

NRS 278.586 also specifies that the County may mandate residential fire suppression systems in new homes with livable area greater than 5,000 square feet without requiring either of the two criteria mentioned above. Thus, acceptance of this study and a subsequent County Mandate for the installation of residential fire sprinklers would mean that all new residential construction (regardless of size) would be required to have automatic fire sprinkler systems installed.

Before the decision of Clark County to consider this legislation, the City of Las Vegas (in 2015) elected to consider adopting a residential fire suppression system mandate. At that time, the Southern Nevada Home Builders Association commissioned a local analytical company, Applied Analysis, to perform a cost-



Final Report

benefit analysis to determine the financial feasibility of such a mandate. Applied Analysis used the 2007 NIST Study (referenced above) as a baseline document. Then, using only local Clark County (Nevada) data plugged-into the NIST-developed algorithms, Applied Analysis performed a study to determine if there was, indeed, a cost benefit to the homeowner derived from having a residential fire suppression system installed. Applied Analysis concluded:

- The National Study found that sprinkler systems are economical (i.e., the benefits outweigh the costs) based on national data; however, the utilization of local datasets leads to a different conclusion. Based on the cost-benefit analysis conducted and described herein, results indicate that in unincorporated Clark County, home fire sprinkler systems are not economical (i.e., the costs outweigh the benefits of installation) based on local fire probabilities and system installation costs. (Reference: Applied Analysis Study, page 3)

Observations:

As was the case in 2017 (when the UNLV Study was completed and subsequently endorsed (unanimously) by the Las Vegas City Council and is the case today), this author does not disagree with the basic research, nor the algorithms utilized by either the NIST Study or the Applied Analysis Study. Both are excellent documents, and along with the UNLV Study, form a solid basis for this particular study.

The Applied Analysis study did not dispute the factual content of the NIST Study. Further, Applied Analysis did not suggest that the data used by NIST was flawed; the cost-benefit algorithms developed by NIST were incomplete; nor were the conclusions reached by NIST deemed faulty. Rather, Applied Analysis simply stated that when local Clark County (Nevada) data is plugged into the NIST-developed algorithms, then the installation costs of a residential fire suppression system appear more expensive than any potential financial benefit for a homeowner. **This conclusion was not accurate in 2017 and it is not accurate in 2023.**

Neither the NIST nor the Applied Analysis studies integrated the new home value appreciation rate for Clark County, Nevada, into their calculations. Additionally, neither study considered the potential economic benefits to the homebuilders and the community, if residential fire suppression systems were mandated in all new residential home construction (regardless of livable space square footage). This study will show that the economic benefits (reduced installation cost-per-square-foot) derived from an increased demand for fire sprinkler systems. This is due to the ability to purchase and maintain larger inventories of fire sprinkler system installation parts and the ability to maintain a trained installation workforce. Further, this study will identify potential accommodations granted to the home builders (with the benefits passed on to the home buyers) if all new housing construction incorporates fire sprinkler systems in the design.

Armed with the three (3) aforementioned studies and updated cost information, HBM Associates commenced its independent study.

Approach:

HBM met with the Clark County Senior Deputy Fire Chief, Kelly Blackmon, and spoke to members of her staff to ascertain specific study objectives and to gain access to relevant fire department regulations and specific Clark County Fire Department (CCFD) structure, manpower, number of personnel, location of fire



Final Report

stations, and response data. Assistant Fire Chief, Danny Horvat was consulted regarding potential modifications to the Clark County Fire Code for new housing developments equipped with automatic fire sprinkler systems.

HBM also met with the Las Vegas Fire Rescue (LVFR) Fire Marshals. These individuals have the most recent and relevant experience with the installation, inspection, and employment of residential fire sprinkler systems in the Las Vegas. HBM met with members of the Southern Nevada Homebuilders Association (SNHBA) and solicited their inputs to this study. Additionally, HBM conducted extensive interviews, took detailed notes, and obtained a wealth of background studies on residential fire suppression systems performed over the past 15 years. Further, HBM met with the major residential suppression installation contractors to determine if any expected or unexpected issues have arisen since the Las Vegas City Residential Fire Sprinkler Ordinance was enacted. Also, HBM wanted to know if the anticipated reduction in costs of installation due to increased fire sprinkler demand had, in fact, been realized.

The researcher also contacted fire marshals, insurance companies, and analytical companies from across the nation. Specifically, they contacted Verisk Analytics:

Verisk Analytics, Inc. is an American data analytics and risk assessment firm based in Jersey City, New Jersey, United States, serving customers worldwide in insurance, natural resources, financial services, government, and risk management.

Each of the organizations and individuals provided the HBM with updated information. As was the case in the UNLV Study, this additional data (beyond simply just the cost of installation) was factored into this study. This new data coupled with actual (and projected) fire sprinkler system installation costs provides Clark County with comprehensive information upon which to make a final decision as to how to proceed with residential fire suppression system legislation.

Findings:

- **Costs & Benefits:** HBM performed an in-depth cost analysis (all cost figures are in 2023 \$\$). The calculations show that a residential fire sprinkler system pays for itself in a matter of months after the new residential home is complete ([See Attachment 2 – 4 for details](#)):
 - **Costs:**
 - The median price for a new home in Clark County is: \$440,000.
 - The average cost per sq. foot for new home construction is \$243 per sq. foot.
 - The median size of a new home in Clark County is: 1,811 sq. feet.
 - Total Cost (Sprinkler Installation + Building Permit Additive + Inspection) = \$1,586.90
 - The installation cost of fire sprinkler systems = \$.80 per sq. foot = \$1,448.80.
 - One (1) fire sprinkler per every eighty (80) sq. feet = 27 sprinklers for median house (although 30 sprinkler heads recommended for safety).
 - Additional building permit fees derived from increased value of home = \$13.60.
 - CCFD Inspection of Fire Sprinklers (\$90 + \$1.15/sprinkler head) = \$124.50.



Final Report

- Benefits: (See Attachments 2, 2a, and 2b)
 - Annual U.S. National Inflation: 4.93%
 - New Homes in Clark County are projected to appreciate in value each year by **2.5%**.
 - The Federal Discount Rate is: 5.25%
 - Homeowners Insurance Annual Premium Reduction (due to installation of fire sprinklers) = \$80.
- Results:
 - Benefit After One (1) Year Occupancy (using Inflation rate of 4.93% only): \$21,765.
 - Profit After One (1) Year Occupancy (using Inflation rate of 4.93% only): \$19,092.
 - Benefit After One (1) Year Occupancy (using 2.5% housing escalation) = \$11,073.
 - Profit After One (1) Year Occupancy (using 2.5% housing escalation) = \$8,934.
 - Attachments 3 and 4 factor-in the additional savings derived by the National Institute of Standards & Technology (NIST) and Applied Analysis respectively.
 - This study accepted the assumptions and the algorithms developed by NIST for “Fatalities/Injuries/Direct & Indirect Property Damage Averted,” as a result of having residential fire sprinkler systems installed in a new home. However, these cost figures were in 2005 dollars, so (as **Attachment 3** explains) these cost figures were converted to 2023 dollars.
 - This study also accepted the assumptions and use of the NIST-developed algorithms used by Applied Analysis. The principal difference between the Applied Analysis Study and NIST was that Applied Analysis utilized Clark County statistics (rather than National averages) when employing the NIST-developed algorithms. (See **Attachment 4**).
 - Finally, this study elected to use the lower insurance premium reduction numbers to maintain consistency between all three (3) cost matrices (**Attachments 2, 3, and 4**).
- Conclusions:
 - **Residential Fire Sprinkler Systems are Cost Effective:** As demonstrated in Attachments 2,3, and 4, residential fire sprinkler systems installed in new homes in Clark County will pay for themselves before the end of one (1) year of occupancy. This is due to two (2) major factors:
 - **Home Appreciation:** Clark County is projected to continue to experience a modest 2.5% appreciation in new home prices for the foreseeable future. **Even ignoring home appreciation, today’s inflation rate still means the sprinkler system cost is absorbed in the increased value of a home within a few months of purchase.**
 - **Reduced Cost of Residential Fire Sprinkler System Installation:** Following the enactment of the 2018 Fire Sprinkler Mandate by the City of Las Vegas, the major fire sprinkler installation firm noticed a drop in the cost to the home builder of \$.15/sq. ft (from \$.95 to the current \$.80/sq ft). This is due to the ability to purchase and maintain larger inventories of fire sprinklers and associated equipment, as well as the ability to keep a trained workforce. While it is anticipated that there could be some additional cost savings, if Clark County enacts a similar ordinance, the price is not



Final Report

expected to drop below \$.80/sq. ft. (This original prediction has been satisfied. Current installation is \$.80/sq ft.)

- **Potential Incentives for Homebuilders and Developers:** Title 13 provides that the designated fire code official has significant latitude to negotiate potential cost savings incentives with homebuilders and developers. As specified in Section 101.6 (Supplemental Rules and Regulations): “The fire code official is authorized to render interpretations of the code and make and enforce rules and supplemental policies, regulations, and guidelines in order to carry out the application and intent of its provisions.” In furtherance thereof, the Clark County Fire Chief, other appropriate Clark County officials, and the homebuilders/developers have discussed and negotiated terms and conditions regarding the incorporation of fire sprinkler systems in future residential, single-family communities. The CCFD Chief has granted the following concessions to the Southern Nevada Home Builders Association (SNHBA):
 1. Fire Chief agrees to allow an exemption from the new sprinkler requirements for projects with an approved tentative map within 180 days from the passage of the ordinance.
 2. Fire will commit to providing next-day sprinkler inspections for residential sprinklers.
 3. Fire will work to incorporate residential sprinklers into the Building Department standard plan process.
 4. Homebuilders requested a solution for ceiling heights greater than 24 feet. Fire included language in the ordinance which eliminates the need for an Alternate Means report every time there are high ceilings.
 5. Homebuilders requested an alternative to the minimum 10 psi safety factor. Fire included language in the ordinance which provides an acceptable alternative to the 10-psi safety factor.
 6. Homebuilders requested relief from the existing code requirement regarding upgrading fire sprinklers in single-family homes. Fire included changes to the mitigation matrix so single-family homes will not be required to install NFPA 13R or NFPA 13 systems.
 7. Homebuilders requested a longer dead-end street length. Fire included language in the ordinance which extends the length of RTC turn-arounds to 600 feet where 500 feet was the previous limit.
 8. Homebuilders requested residential fire statistical data reporting. Fire will provide reports similar to what CLV provides to the homebuilders.
 9. Homebuilders requested a reduction in the requirements for secondary access. Upon researching this request, it was determined that Fire does not currently place limits regarding secondary access.
 10. Homebuilders requested an increase in required hydrant spacing. Fire pointed out that current code already allows increased spacing for sprinklered homes.
 11. Homebuilders requested to use ¾” water meters. Fire pointed out that current code already allows this depending upon proving the hydraulic demand.



Final Report

12. Homebuilders requested to use narrower streets in areas with sprinklered homes. Fire denied this request and will remain with the current code requirements for street widths.
 13. Homebuilders requested to eliminate fees for residential fire sprinkler permitting. Fire denied this request; minimum fees will apply per the adopted fee schedule.
- - **NRS 278.586 Requirements Satisfied:** In every case, the economic benefits of having residential fire sprinkler systems installed were apparent. Nevertheless, as was discussed in the UNLV Study, cost should not be the overriding factor as to whether a municipality should or should not mandate residential fire sprinkler systems in all new home construction. Life and safety should be the overriding concerns (as will be discussed in the next section of this report).

Life & Safety:

During the course of this study, HBM Associates studied the Clark County Fire Department and its responsibility to provide fire protection to a very large geographical area. To meet the response standards, as set forth in National Fire Protection Association (NFPA) 1710 (Standards “*Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*” 2020 edition), CCFD must maintain a large number of firefighters, emergency personnel, and support staff located at strategic locations around Clark County.

- **NFPA 1710:** According to NFPA 1710, Section A.4.1.2.1(3), CCFD’s goal is to plan and situate its resources, so that it can receive a fire emergency call and process it in less than 60 seconds, utilize up to 80 seconds for turnout, then:

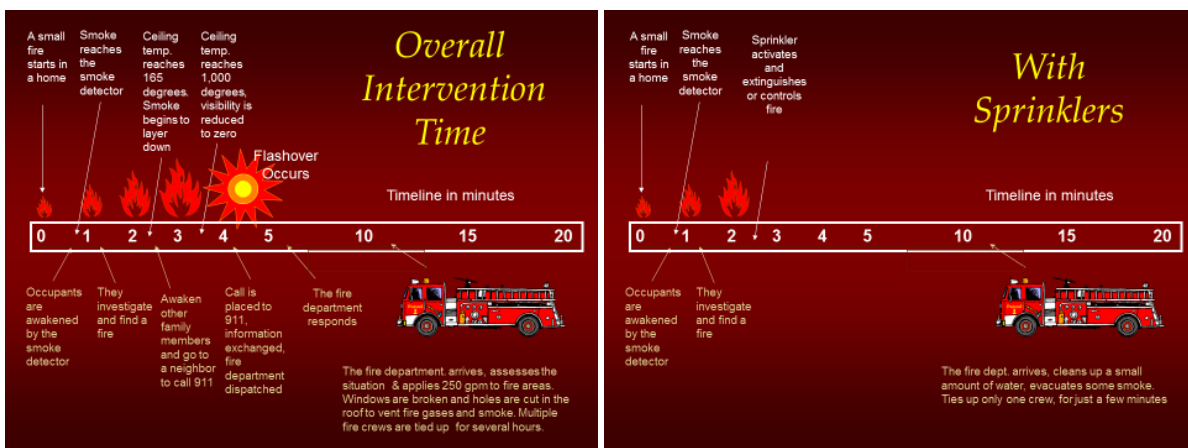
“... to consistently meet a 240-second travel time for the initial company fire suppression response; for other than high-rise, a 480-second travel time for the full alarm fire response assignment; and for high-rise, a 610-second travel time for the full alarm fire response assignment.”

- **CCFD Response Time:** In order to meet NFPA 170 standards, CCFD should have its first unit arriving at the scene of an incident at approximately seven (7) minutes after the initial notification of a fire. CCFD has consistently achieved the goal approximately 78% of the time, while continuing to improve each month. To provide some appreciation for the size of the problem, the following information is provided:
 - **Size:** Clark County, Nevada, which covers 8,061 sq. miles, is about the size of New Jersey. Its population is more than 2 million people and, because it is home to Las Vegas, the county experiences more than 40 million visitors per year. Of the 2 million residents, approximately 1,200,000 people live in the unincorporated areas of the County.



Final Report

- **Clark County Fire Department (CCFD):** Within the County, the cities of Las Vegas, Boulder City, North Las Vegas, Henderson, and Mesquite their own fire departments. However, this means the preponderance of the County’s fire protection responsibilities fall under the CCFD. To meet this challenge, CCFD has:
 - 31 Full-Time Fire Stations
 - 10 Rural Fire Stations with 130 volunteer firefighters
 - 836 full-time personnel, which include:
 - 685 Authorized Suppression (Fire Fighting) Personnel
 - 82 Fire Prevention Personnel
 - 69 Support Staff Positions
- **Reality:** While all fire departments across-the-nation continue to work on arriving on-scene within the guidelines specified in NFPA 1710, it is clear that any arrival time beyond four (4) to five (5) minutes after a house fire begins may be, in-fact, too late.
- **Smoke Detectors – A Case of Too Little, Too Late:** Smoke detectors without residential fire suppression systems do not appear to be enough to save lives and/or avert major home damage.
 - Smoke detectors do not provide sufficient warning to save all lives. In a typical residential house fire, they activate at about the 45 second point after a fire has started. Smoke becomes a visibility problem at 2 ½ minute point. Temperatures reach more than 1,000 degrees in about 4 minutes. Delays in notification (occupants waking up; assessing & identifying the problem; insuring humans and pets are alerted; then calling 911) means the Fire Department commences response at approximately the 5-minute point. It takes (on average) 10 minutes (total elapsed time) for the fire department to arrive. (Source: Power Point Presentation “Why Sprinklers?”) By that time, the residence is fully involved in the fire.



Fire Suppression in Homes with and without Sprinkler Systems

(Source: “Residential 1-2 WHY SPRINKLERS” Presentation by Roy Marshall)



Final Report

- **Damage to Home:** Beyond fire and smoke damage, there is a significant amount of water and structural damage to a house that has experienced a fire.
 - Residential sprinkler systems are set to activate at 150 degrees F.
 - The average residential sprinkler system outputs water at an average of 13 gallons per minute (GPM).
 - Given average fire department response times, a residential sprinkler head may output less than 200 gallons of water before being shut off by a fireman.

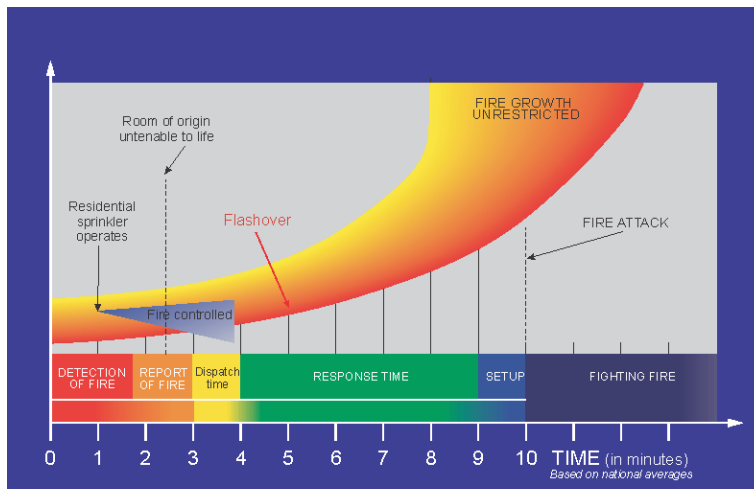


Figure 3: Positive Effects of Residential Sprinklers

(Source: "Why Sprinklers" Power Point Presentation by Pat Coughlin)

- Unprotected residential dwellings will require between 1,500 and 100,000 gallons of water to extinguish the blaze. (This figure does not include damage to doors, windows, and the roof as the fire department works to enter the home.)
- **The Danger in Synthetics:** When a house is on fire, many times it is not the structural fire that causes fire deaths, it is the synthetic composition of the residential contents. (Synthetics burn twice as hot and twice as fast.) (Source: Power Point Presentation "Why Sprinklers?") Additionally, synthetic materials will typically outgas extremely hazardous and toxic smoke clouds.
 - During a fire, temperatures in a house (without fire suppression systems) can reach 1200 degrees F in less than 5 minutes.
 - "Thermal burns and smoke inhalation were the primary symptoms leading to death, accounting for 90 percent of all fatalities in residential fires." [Source: Topical Fire Report Series, Volume 16, Issue 2 / July 2015, "*Civilian Fire Fatalities in Residential Buildings (2011-2013)*"]
- **Fatalities:** Residential Fire Sprinkler Systems save lives. According to an extensive study performed by the Medford (Oregon) Fire Department:
 - Home fire sprinklers are designed to ensure a tenable atmosphere for escape.
 - Fire sprinklers with smoke detectors increases chance of surviving a fire by over 97%.



Final Report

- Smoke detectors aren't enough.

(Source: Power Point Presentation "The Case for Residential Sprinklers in Medford, Oregon.")

- **Modern Home Building Trends:** New trends in home building and modern furnishing are compressing the timelines between a fire starting, toxic smoke release, and flashover occurring. It is important to note that Residential occupancies are required by the International Residential Code (IRC) and International Energy Conservation Code (IECC) to limit air leakage to prevent conditioned air escaping the dwelling. This approach to energy savings has created a condition to limit the escape of smoke and fire gases in the case of a fire condition within the dwelling. The combination of fire gases from synthetic materials with limited ability to vent causes fires to reach flashover potential within three minutes of ignition.
 - The Federal Emergency Management Agency (FEMA) and the US Fire Administration hosted a two-day workshop at the Maryland Fire & Rescue Institute (College Park, MD) on 11-12 Dec 2012. This workshop was attended by leading experts from the fire service and home fire research specialists, who gave compelling presentations on how the latest trends in homebuilding and residential furnishing are cause for concern. What they revealed is that there is not only increased concern for the residents, but substantially increased risks for the firefighters as they combat fires in newer residential homes. Their observations are summarized as follows:
 - **Changes in the Design of New Homes**
 - Larger home footprints.
 - Open concept floor plans.
 - More unventilated attics.
 - Increasingly airtight construction.
 - Increased concealed space.
 - Variety in plans and construction types.
 - Increased housing density.
 - Building at the wildland interface.
 - **Changes in Home Construction Materials and Techniques**
 - Engineered wood assemblies.
 - Combustible exterior finishes.
 - Green building features.
 - **Changes in Home Furnishings**
 - New information on effectiveness and hazards of fire-retardant chemicals in upholstered furnishings.
 - Overall increased plastic contents.
 - Energy-saving technologies.
 - Photovoltaics.
 - Electric vehicles.
 - Energy storage and distributed power solutions.
 - **Changing Fire Service-related Risks**
 - Shorter time available for size up due to reduced times to flashover.



Final Report

- Fire flow/Wind-driven fires phenomena.
- Current fire ground procedures and firefighter training inadequate to address those new risks.
- Less experience in fighting fires due to fewer fires.
- Staffing reductions in selected jurisdictions independent of increased risks.
- New firefighter gear/tools with varying performance levels.
- Firefighter gear improvements increasing other personnel risks.
- Exposure to carcinogens from contents and construction materials.

(Source: "Changing Severity of Home Fires Workshop Report," US Fire Administration/National Fire Data Center, December 2012)

Title 13 – Clark County Fire Code Amendments (Residential Fire Sprinklers):

(https://www.clarkcountynv.gov/government/departments/building_fire_prevention/codes/index.php)

- **Effective Date.** Effective February 4, 2019, Clark County formally adopted International Fire Code (IFC) 2018 and approved Title 13 – Clark County Fire Code Amendments, which deleted references to IFC 2012,
- **NRS 237.090:** Nevada Revised Statute 237.090 (Attachment 5) requires that a business impact statement be submitted along with any proposed rule change.
 - Based on the major incentives (above) being negotiated with home builders by the Clark Fire Department, this cost benefit analyst study asserts that there will not be adverse effects associated with home building if the Clark County Commissioners enact legislation to mandate the installation of residential fire sprinklers in all single-family residences. The result would be that all new single-family residences, regardless of livable space square footage, would be required to have residential fire sprinkler systems installed.
 - Further, an environmental impact study written by FM Global (a well-known insurance company specializing in loss prevention) further **demonstrates the efficacy** of having automatic fire sprinkler systems installed in single-family dwellings. (This study is discussed more thoroughly in the next section of this paper.)
- **NRS 202.580:** Nevada Revised Statute 202.580 states that anyone who "willfully and maliciously removes, damages or destroys any rope, wire, bell, signal, instrument or apparatus for the communication of alarms of fire or police calls is guilty of an offense proportionate to the value of the property removed, damaged or destroyed, but in no event less than a misdemeanor." The same provisions hold true for residential fire sprinkler systems. (Attachment 6) Installation contractors are aware of this law and new homeowners need to be made aware of this law. Once installed no one is permitted to tamper with or disable residential fire sprinkler systems.



Final Report

Henderson, Las Vegas, Reno, Nevada, and the SNHBA

When reviewing the new home permits being issued by Henderson and Las Vegas (both of whom issued ordinances requiring similar legislation in 2011 and 2018 respectively), one can see that there has not been a significant downturn in new home construction in either municipality (see Attachments 7a and b). In fact, overall building trends in both cities remain nearly constant and, in the case of Las Vegas, show an increase in building permits being issued...**after the fire sprinkler ordinance was enacted**. Reno enacted a modified version of the fire sprinkler ordinance, which requires all new single-family homes outside of a six (6) minute response time to have automatic fire sprinklers installed (see attachment 7c.)

- **Henderson, Nevada:** The Henderson City Council approved an ordinance in 2010, which required all new single-family dwellings (less than 5,000 square feet of living space) to have residential fire sprinkler systems installed. The ordinance became effective in July 2011. Henderson was the first city in the State of Nevada to successfully demonstrate the economic efficiency of installing residential fire sprinkler systems in homes and provided the City Council with factual evidence that loss of life and major property damage could be averted in most cases when a home was equipped with automatic fire sprinklers. Attachment 6a demonstrates that this ordinance had no effect on the single-family housing building trends in Henderson. In fact, they continued at rates comparable to building rates prior to the effective date of the ordinance.
- **Las Vegas, Nevada:** The Las Vegas City Council accepted the cost benefit analysis provided by UNLV and enacted an ordinance requiring automatic fire sprinkler systems in all new residential construction (5,000 square feet or less) in February 2018. Attachment 6b demonstrates that new family homes building was not affected by implementation of this ordinance.
- **Reno, Nevada:** The Reno, Nevada City Council adopted a modified ordinance in 2019, whereby residential homes (5,000 square feet or less) located outside of a six (6) minute response time were required to be equipped with automatic fire sprinkler systems. The Reno Fire Department used an environmental impact study to demonstrate to their City Council the positive environmental effects of residential fire sprinkler systems. This study was written by FM Global and entitled: "Environment Impact of Automatic Fire Sprinkler Systems," <<https://www.fmglobal.com/~media/Files/FMGlobal/Research%20Technical%20Reports/p10062.pdf>>. FM Global is

"...an American mutual insurance company based in Johnston, Rhode Island, United States, with offices worldwide, that specializes in loss prevention services primarily to large corporations throughout the world in the Highly Protected Risk property insurance market sector." (Wikipedia)

- FM Global's Research Technical Report showed:
 - Automatic fire sprinkler systems significantly reduced greenhouse gas emissions (carbon dioxide, methane, and nitrous oxide) by 97.8% in the event to a fire.
 - Water usage in fighting a residential fire could be reduced as much as 91% over fighting a similar fire with firefighting equipment.



Final Report

- Flashovers never occurred in test rooms protected by automatic fire sprinklers, while flashovers occurred at approximately 5 minutes after ignition in non-sprinkled test rooms.
- **Southern Nevada Home Builders Association (SNHBA):** The Executive Director, SNHBA, Nat Hodgson, was referenced in the minutes of a June 22, 2021, meeting of the Nevada Energy Code Collaborative Meeting (Attachment 8). He stated that even though we were experiencing: “the ongoing hangover from COVID, but this is the strongest year in housing in the Valley since 2007.”

What this means is that despite the residential water sprinkler ordinances issued by Henderson and Las Vegas respectively; after the October 1, 2017, mass shooting at the Route 91 Music Festival; and after the COVID-19 pandemic, new housing starts in Southern Nevada continued to grow unabated. Thus, it appears that there no long-term downturn in new home construction in Southern Nevada. It seems that any decrease in home building, Mr. Hodgson noted in the same meeting, is because: “Some builders have intentionally slowed down because of the labor issues.” (See Attachment 8)

Final Thoughts:

- **Cost is the wrong metric:** The cost of installation is not a core issue. While important, cost savings should not be the primary issue. In HBM’s opinion, cost should not be used as the sole criterion for accepting or rejecting the provisions contained in NRS 278.576. The real issues are: “Do fire suppression systems work and do they save lives and property?” The answer to both questions is: “Yes.” Residential Fire Sprinkler systems pay for themselves. So, if cost is not the main issue, what is? The core issue is Safety.
- **Safety is the Paramount Issue:** Abraham Maslow, noted American psychologist, developed a concept called the Hierarchy of Needs. The most fundamental human need is Safety. While fire alarms provide some level of warning, they do not provide sufficient notification to the occupants of a burning home to allow the occupants to get to safety in a reliable manner. Residential sprinkler systems are designed to put water on the ignition source of a home fire, while allowing the resident to escape safely. Thus, residential fire sprinkler systems in new homes speaks to the most fundamental human need – Safety.
- **Value Proposition-Community/Home Buyer/Home Builder:** As Clark County considers this recommendation, it is important to summarize the respective value of automatic residential fire sprinkler systems to three major groups: (See Attachment 9)
 - The Community
 - The Home Buyer
 - The Home Builder



Final Report

Recommendation:

The Clark County Commissioners should immediately pass the ordinance mandating fire sprinkler systems for all new single-family residential home construction.



Final Report

ATTACHMENTS

Attachment 1

Nevada Revised Statute (NRS) 278.586

Adoption of building code or other action by local government requiring installation of automatic fire sprinkler system in new residential dwelling units and other structures.

1. A governing body may adopt a building code or take any other action that requires the installation of an automatic fire sprinkler system in a new residential dwelling unit that has an area of livable space of 5,000 square feet or more.

2. Except as otherwise provided in subsection 3, a governing body may, on or after July 1, 2015, adopt a building code or take any other action that requires the installation of an automatic fire sprinkler system in a new residential dwelling unit that has an area of livable space of less than 5,000 square feet only if, before adopting the building code or taking the action, the governing body:

(a) Conducts an independent cost-benefit analysis of the adoption of a building code or the taking of any other action by the governing body that requires the installation of an automatic fire sprinkler system in a new residential dwelling unit that has an area of livable space of less than 5,000 square feet: and

(b) Makes a finding at a public hearing that, based on the independent cost-benefit analysis conducted pursuant to paragraph (a), adoption of the building code or the taking of any other action by the governing body that requires the installation of an automatic fire sprinkler system in a new residential dwelling unit that has an area of livable space of less than 5,000 square feet is to the benefit of the owners of the residential dwelling units to which the requirement would be applicable and that such benefit exceeds the costs related to the installation of automatic fire sprinkler systems in such residential dwelling units.

3. A governing body may require the installation of an automatic fire sprinkler system in a new residential dwelling unit that has an area of livable space of less than 5,000 square feet without conducting the analysis or making the findings required by subsection 2 if the governing body makes a determination at a public hearing that the unique characteristics or the location of the residential dwelling unit, when compared to residential dwelling units of comparable size or location within the jurisdiction of the governing body, would cause an unreasonable delay in firefighter response time. In making such a determination, the governing body may consider:

(a) The availability of water for use by firefighters in the area in which the residential dwelling unit is located.

(b) The availability to firefighters of access to the residential dwelling unit;

(c) The topography of the area in which the residential dwelling unit is located; and

(d) The availability of firefighting resources in the area in which the residential dwelling unit is located.

4. A governing body shall not adopt a building code or take any other action that requires the installation of an automatic fire sprinkler system in a structure other than a residential dwelling unit or any portion of such a structure, whether located on public or private property:

(a) That is covered but not completely enclosed;



Final Report

- (b) That is used primarily for agricultural, livestock or equestrian activities;
- (c) That has spectator seating situated around the perimeter of the structure or portion thereof; and
- (d) Which is otherwise in compliance with all relevant building codes concerning exits and fire alarm systems.

5. The provisions of this section do not prohibit:

- (a) A local government from enforcing an agreement for the development of land which requires the installation of an automatic fire sprinkler system in any residential dwelling unit; or
- (b) A person from installing an automatic fire sprinkler system in a structure described in subsection 4 or any residential dwelling unit.

6. As used in this section:

- (a) "Automatic fire sprinkler system" has the meaning ascribed to it in [NRS 202.580](#).
- (b) "Residential dwelling unit" does not include a condominium unit, an apartment unit or a townhouse unit that shares a common wall with more than one other such unit.

(Added to NRS by [2015, 1989](#))



Final Report
Attachment 2

Cost Algorithms Explanations

Attachments 2, 3, and 4 use cost analysis terminology that may be unfamiliar to some individuals reviewing this report; therefore, the following definitions and accompanying explanations are provided:

- **Median Sales Price:** \$440,000. Clark County new home prices in early 2023 have stabilized, although it prices are expected to grow modestly over the foreseeable future. (https://www.realtor.com/realestateandhomes-search/Clark-County_NV/overview)
- **New Home Appreciation Rate:** 2.5% (<https://www.rockethomes.com/real-estate-trends/nv/clark-county>)
- **National Inflation Rate:** 4.93% (<https://www.usinflationcalculator.com/inflation/current-inflation-rates/>)
- **Median Size New Home:** 1,811 square feet (https://www.realtor.com/realestateandhomes-search/Clark-County_NV/overview)
- **Sprinkler Installation and Associated Fees:** Cost of Sprinkler Installation/Building Permit Fee (increase due to value of sprinkler system)/Fire Dept. Inspection: \$1,448.80 (sprinkler cost of \$.80/sq ft) + \$13.60 + \$124.50 = \$1,880.60. (http://clarkcounty-nv.elaws.us/code/coor_title13_ch13.04_sec13.04.070) (<http://www.clarkcountynv.gov/building/Pages/PermitFeeCalculator.aspx>)
- **Insurance Premium Discount:** \$80 annual policy discount (<http://nfpa.org>). Derived by taking lowest cost homeowners coverage for State of Nevada (\$1,150) times insurance average of 7% discount on fire proportion of homeowners policy for having automatic fire sprinkler system installed. (<https://www.moneygeek.com/insurance/homeowners/best-cheap-homeowners-insurance-nevada/#cheapest-insurance-in-nevada>)
- **Federal Discount Rate:** .25%. The interest rate established by the Federal Reserve and used for discounting. The discount rate represents the minimum acceptable rate of return on investment. (This means the present value of \$1.00 earned in 2024 is \$.9975 in 2023.) ([National Institute of Standards and Technology, Office of Applied Economics, "Benefit-Cost Analysis of Residential Fire Sprinkler Systems," NISTIR 7451, pg.3, September 2007](#))
- **Free Cash Flow (FCF):** The cash the new home generates due to the appreciation of the house each year + homeowners insurance premium reduction (due to installation of fire sprinkler system, which is paid off after just a few months in the home).
 - **Discounted FCF:** This is applying the Federal Discount Rate to FCF (the amount the house appreciated in Year 1) and determining the present value in 2023 \$. Also, the cost of sprinkler installation and associated fees is subtracted from the home's appreciation.
 - **What Does This Mean?** This means the entire cost of the sprinklers is absorbed by the increased value of the home within the first few months of home occupancy regardless of using the National Inflation percentage (4.93%) or the escalation in Clark County home values (2.5%).



**Final Report
Attachment 2a**

**Cost Benefit Analysis for Median Sized New Home in Clark County, NV
(National Inflation Rate Only = 4.93%)**

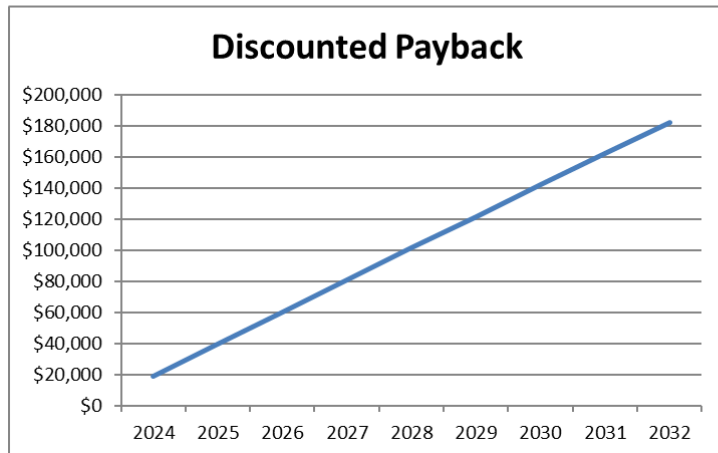
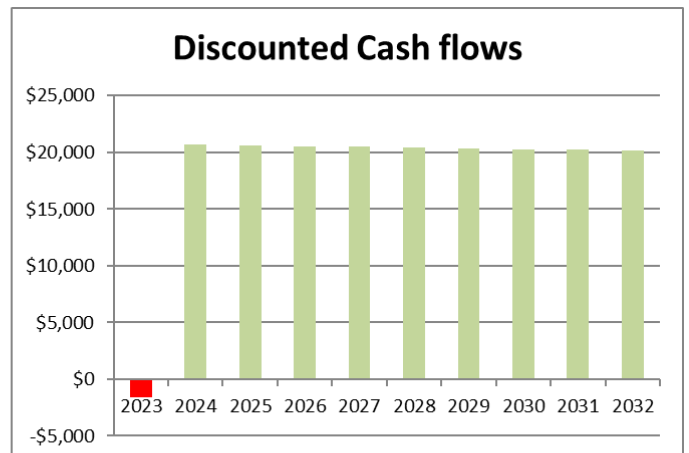
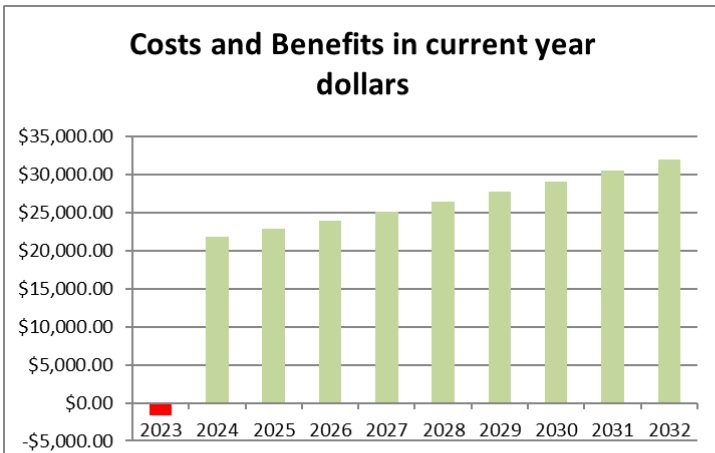
Clark County Fire Department Cost Benefit Analysis for 2023 Median Sized Home										
(Assuming no independent escalation of home values, but using only the National Inflation Rate)										
Median Sales Price:										
\$440,000										
Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Fire Sprinkler Cost	-\$1,586.90									
National Inflation Rate (4.93%)		\$21,692	\$22,761	\$23,884	\$25,061	\$26,297	\$27,593	\$28,953	\$30,381	\$31,878
Insurance Premium Credit		\$73	\$73	\$73	\$73	\$73	\$73	\$73	\$73	\$73
Total Benefits Per Year/ FCF	-\$1,586.90	\$21,765	\$22,834	\$23,957	\$25,134	\$26,370	\$27,666	\$29,026	\$30,454	\$31,951
Cumulative Benefits	\$238,227									
Discount Factors										
Discount Rate	5.25%									
Base Year	2023									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount Factor	1.0000	0.9501	0.9027	0.8577	0.8149	0.7743	0.7356	0.6989	0.6641	0.6310
Discounted FCF	-\$1,587	\$20,679	\$20,613	\$20,547	\$20,482	\$20,417	\$20,352	\$20,288	\$20,224	\$20,160
Cumulative FCF	-\$1,587	\$19,092	\$39,706	\$60,253	\$80,735	\$101,152	\$121,504	\$141,792	\$162,016	\$182,176
NPV	\$182,184									
IRR	1376%									

1. Median Home Price: \$440,000 (https://www.realtor.com/realestateandhomes-search/Clark-County_NV/overview)
2. Median Clark County (NV) Home Size: 1,1811 sq. feet (<https://www.zillow.com/clark-county-nv/home-values>)
3. Clark County new home cost per square foot: \$243 (median home price/median home size in square feet)
4. Number of Sprinkler Heads Required for Median Home: 1,811. ft/80 sq. feet/sprinkler head = 27 Sprinkler Heads; however, 30 Sprinkler Heads recommended by On Guard Protection for increased safety margin.
5. Cost of Sprinkler Installation (including materials & labor) = \$.80/square foot = \$1,448.80. (On Guard Fire Protection, Inc.)
6. Cost of Sprinkler Installation/Building Permit Fee (increase due to value of sprinkler system)/Fire Dept. Inspection: \$1,448.80 + \$13.60 + \$124.50 = \$1,586.90.
(http://clarkcounty-nv.elaws.us/code/coor_title13_ch13.04_sec13.04.070)
(<http://www.clarkcountynv.gov/building/Pages/PermitFeeCalculator.aspx>)
7. Insurance Premium Reduction is lowest reduction found: \$73 annually (<https://blog.qrfs.com/17-fire-sprinklers-pay-for-themselves-through-homeowners-insurance-discounts/>)
8. National Inflation Rate: 4.93% (<https://www.usinflationcalculator.com/inflation/current-inflation-rates/>)
9. Federal Discount Rate: 5.25% (<https://www.thebalance.com/federal-reserve-discount-rate-3305922>)
10. Free Cash Flow (FCF) represents the cash an entity (i.e., a house) generates after cash outflows to support operations. The cash the house generates is the appreciation of the house each year + homeowners insurance premium reduction (due to installation of fire sprinkler system).
11. Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time (in our study, this period of time is 10 years). The net present value or net present worth applies to a series of cash flows occurring during each of the 10 years. The present value of a cash flow depends on the number of years between now and the cash flow. It also depends on the discount rate. NPV accounts for the time value of money.
12. Internal rate of return (IRR) is annualized rate of earnings on an investment (the interest rate on the all the accrued increased value of the home over the 10 years).



Final Report
Attachment 2a

Cost Benefit Analysis for Median Sized New Home in Clark County, NV
(National Inflation Rate Only = 4.93%)
(Depicted Graphically)





**Final Report
Attachment 2b**

**Cost Benefit Analysis for Median Sized New Home in Clark County, NV
(Home Appreciation Only = 2.5%)**

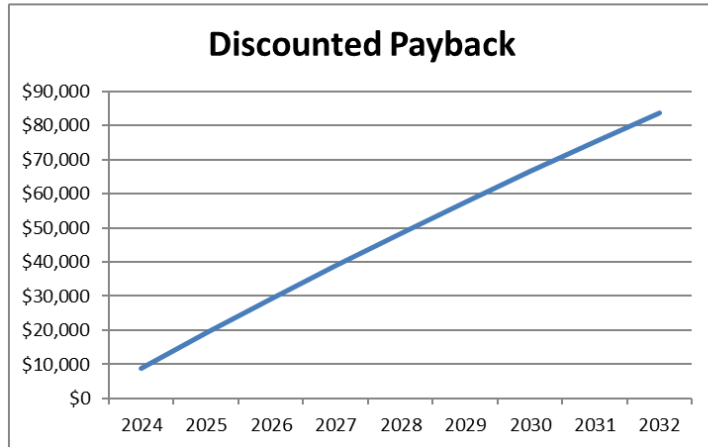
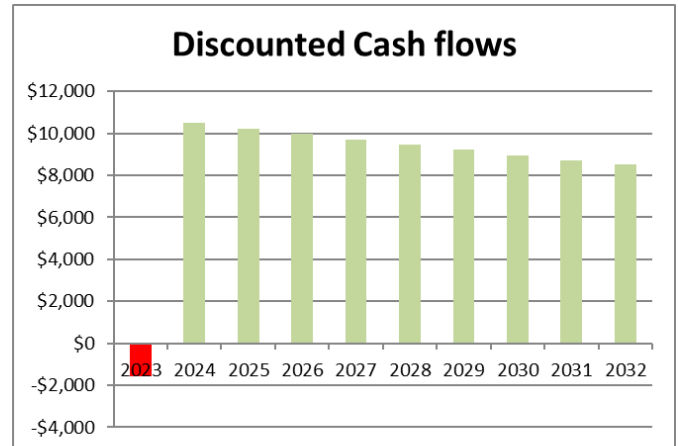
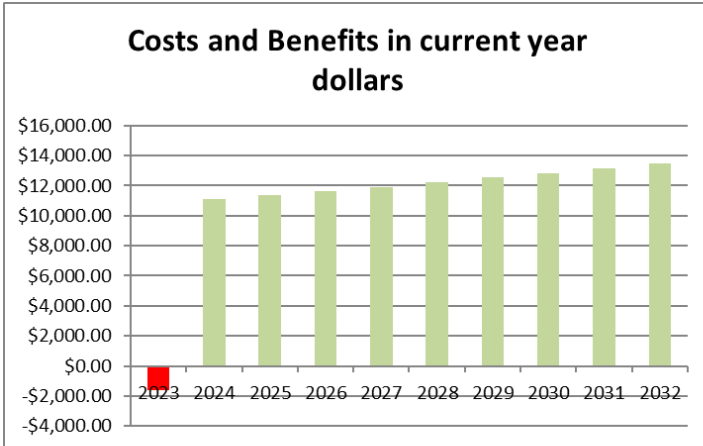
Clark County Fire Department Cost Benefit Analysis for 2023 Median Sized Home										
(Assuming Zero Inflation Rate & Using Only The Projected Increase in New Home sales prices due to demand)										
Median List Price:										
\$440,000										
Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Fire Sprinkler Cost	-\$1,586.90									
Home Appreciation (2.5%)		\$11,000	\$11,275	\$11,557	\$11,846	\$12,142	\$12,445	\$12,757	\$13,076	\$13,402
Insurance Premium Credit		\$73	\$73	\$73	\$73	\$73	\$73	\$73	\$73	\$73
Total Benefits Per Year/ FCF	-\$1,586.90	\$11,073	\$11,348	\$11,630	\$11,919	\$12,215	\$12,518	\$12,830	\$13,149	\$13,475
Cumulative Benefits	\$109,227									
Discount Factors										
Discount Rate	5.25%									
Base Year	2023									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount Factor	1.0000	0.9501	0.9027	0.8577	0.8149	0.7743	0.7356	0.6989	0.6641	0.6310
Discounted FCF	-\$1,587	\$10,521	\$10,244	\$9,975	\$9,713	\$9,458	\$9,209	\$8,967	\$8,732	\$8,502
Cumulative FCF	-\$1,587	\$8,934	\$19,178	\$29,153	\$38,866	\$48,323	\$57,532	\$66,500	\$75,231	\$83,734
NPV	\$83,742									

1. Median Home Price: \$440,000 (https://www.realtor.com/realestateandhomes-search/Clark-County_NV/overview)
2. Median Clark County (NV) Home Size: 1,1811 sq. feet (<https://www.zillow.com/clark-county-nv/home-values>)
3. Clark County new home cost per square foot: \$243 (median home price/median home size in square feet)
4. Number of Sprinkler Heads Required for Median Home: 1,811. ft/80 sq. feet/sprinkler head = 27 Sprinkler Heads; however, 30 Sprinkler Heads recommended by On Guard Protection for increased safety margin.
5. Cost of Sprinkler Installation (including materials & labor) = \$.80/square foot = \$1,448.80. (On Guard Fire Protection, Inc.)
6. Cost of Sprinkler Installation/Building Permit Fee (increase due to value of sprinkler system)/Fire Dept. Inspection: \$1,448.80 + \$13.60 + \$124.50 = \$1,586.90.
(http://clarkcounty-nv.elaws.us/code/coor_title13_ch13.04_sec13.04.070)
(<http://www.clarkcountynv.gov/building/Pages/PermitFeeCalculator.aspx>)
7. Insurance Premium Reduction is lowest reduction found: \$73 annually (<https://blog.qrfs.com/17-fire-sprinklers-pay-for-themselves-through-homeowners-insurance-discounts/>)
8. National Inflation Rate: 4.93% (<https://www.usinflationcalculator.com/inflation/current-inflation-rates/>)
9. Federal Discount Rate: 5.25% (<https://www.thebalance.com/federal-reserve-discount-rate-3305922>)
10. Free Cash Flow (FCF) represents the cash an entity (i.e., a house) generates after cash outflows to support operations. The cash the house generates is the appreciation of the house each year + homeowners insurance premium reduction (due to installation of fire sprinkler system).
11. Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time (in our study, this period is 10 years). The net present value or net present worth applies to a series of cash flows occurring during each of the 10 years. The present value of a cash flow depends on the number of years between now and the cash flow. It also depends on the discount rate. NPV accounts for the time value of money.
12. Internal rate of return (IRR) is annualized rate of earnings on an investment (the interest rate on the all the accrued increased value of the home over the 10 years).



Final Report

RESIDENTIAL FIRE SPRINKLER COST BENEFITS DEPICTED GRAPHICALLY
HOME APPRECIATION ONLY = 2.5%
(Depicted Graphically)





Final Report

Cost Benefit Analysis for Median Sized New Home in Clark County, NV (Home Appreciation + NIST-Derived Benefits from Averted Death/Injury/Property Damage)

Clark County Fire Department Cost Benefit Analysis for 2023 Median Sized Home										
(Home Appreciation + NIST Cost Savings)										
Median Sales Price:										
\$440,000										
Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Fire Sprinkler Cost	-\$1,586.90									
Death/Injuries/Direct & Indirect Property Loss Averted Benefits (NIST Study in 2023\$.)		\$369.24	\$369.24	\$369.24	\$369.24	\$369.24	\$369.24	\$369.24	\$369.24	\$369.24
Home Appreciation (2.5%)		\$11,000	\$11,275	\$11,557	\$11,846	\$12,142	\$12,445	\$12,757	\$13,076	\$13,402
Insurance Premium Credit		\$73	\$73	\$73	\$73	\$73	\$73	\$73	\$73	\$73
Total Benefits Per Year/ FCF	-\$1,586.90	\$11,442	\$11,717	\$11,999	\$12,288	\$12,584	\$12,888	\$13,199	\$13,518	\$13,845
Cumulative Benefits	\$112,550									
Discount Factors										
Discount Rate	5.25%									
Base Year	2023									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount Factor	1.0000	0.9501	0.9027	0.8577	0.8149	0.7743	0.7356	0.6989	0.6641	0.6310
Discounted FCF	-\$1,587	\$10,871	\$10,577	\$10,292	\$10,014	\$9,743	\$9,481	\$9,225	\$8,977	\$8,735
Cumulative FCF	-\$1,587	\$9,285	\$19,862	\$30,154	\$40,167	\$49,911	\$59,392	\$68,617	\$77,594	\$86,329
NPV	\$86,337									
IRR	723%									

1. NIST-developed calculations were based on the “National Averages” for “Fatalities/Injuries/Direct & Indirect Property Damage Averted” due to installation of residential fire sprinkler systems. This study accepted the NIST assumptions and calculations; however, the NIST dollar figures were in 2005 dollars. When converted to 2023 dollars = \$369.24 annual savings. In the NISTR 7451 Report (“Benefit-Cost Analysis of Residential Fire Sprinkler Systems”), the NIST authors performed extensive research with the insurance industry and developed definitions for the following terms. The Applied Analysis Study (“Benefit-Cost Analysis of Residential Fire Sprinkler Systems – dated: March 2015) accepted these definitions and the associated calculations as valid. To remain consistent, this author accepts the definitions and calculation also; however, the associated dollar amounts are shown in present-day (2023) dollars. The NIST-developed definitions are as follows:

a. Value of Fatality and Injury Averted: “Assigning a dollar value to a statistical life or injury averted has become a generally accepted part of economic methodology...the empirical estimates of the value of life continue to be subject to controversy and inconsistency...one approach that is consistent with economic theory...is based on the willingness-to-pay concept. Willingness to pay values are computed according to how much decision makers are willing to invest to reduce their risk of death or injury by a certain fraction.”

b. Value of Direct & Indirect Property Loss Averted: This figure (Direct Loss) is a calculation using that fact that “...insurance is assumed to cover 80% of the loss of any property to the owner.” The Indirect Property Loss are “the costs such as temporary shelter, missed work, extra food cost, legal expenses, transportation, emotional counseling, and childcare.”

c. Calculations: NIST developed a series of industry-accepted algorithms, which took the above dollar figures and integrated them into formulas based on the national averages of home fires, resulting injuries, and deaths, as well as direct and indirect costs. They then performed sensitivity analyses over a four (4) year period (2002-2005) using 10,000 samples to come up generally accepted values for each area of “averted” loss.

2. HBM Study elected to use lower (actual) insurance premium savings for State of Nevada = \$80 annual savings.

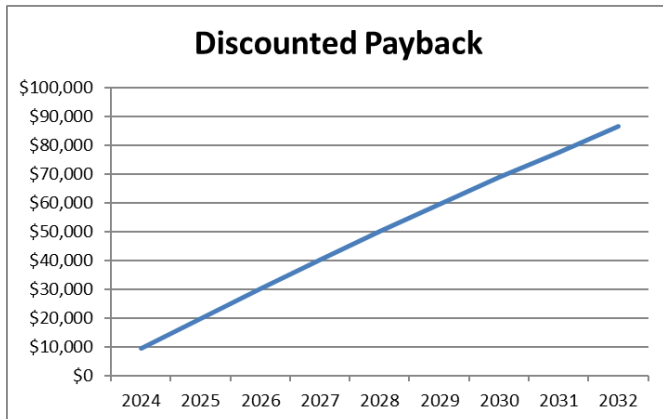
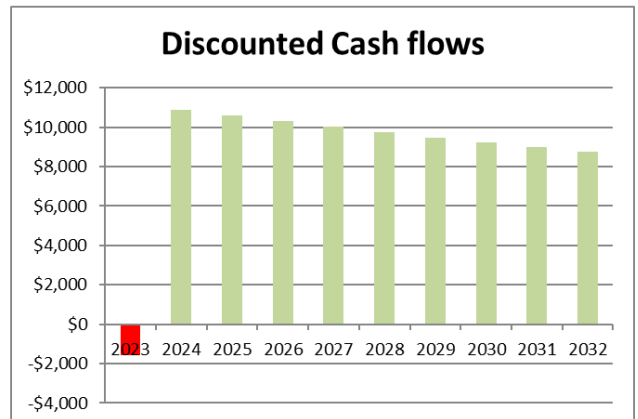
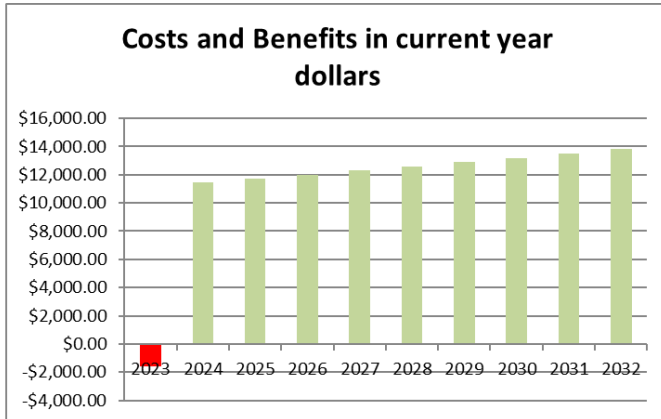
3. HBM Study added the NIST-developed savings + insurance premium savings to the established home appreciation calculations from Attachment 2 to derive the above cost savings.

Attachment 3a.



Final Report

**RESIDENTIAL FIRE SPRINKLER COST BENEFITS DEPICTED GRAPHICALLY
HOME APPRECIATION + NIST-DERIVED DATA
(Depicted Graphically)**





Final Report

**Cost Benefit Analysis for Median Sized New Home in Clark County, NV
(Home Appreciation + Applied Analysis-Derived Benefits
from Averted Death/Injury/Property Damage Specific to Clark County)**

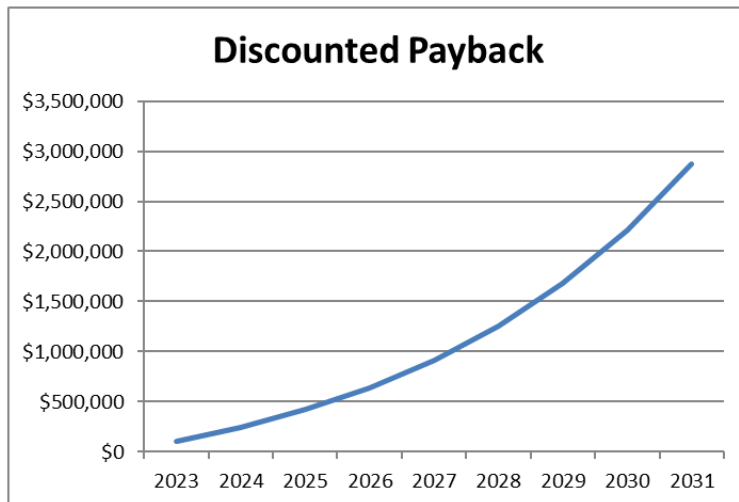
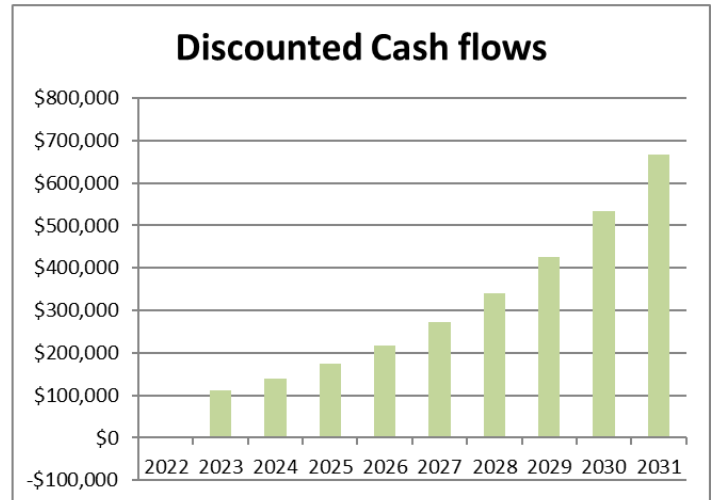
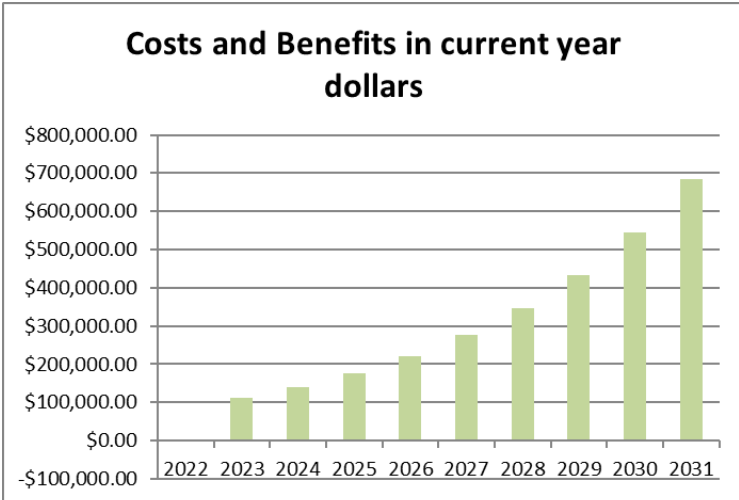
Clark County Fire Department Cost Benefit Analysis for 2022 Median Sized Home										
(Home Appreciation + Applied Analysis Cost Savings)										
Median Sales Price:										
\$440,000										
Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Fire Sprinkler Cost	-\$1,586.90									
Death/Injuries/Direct & Indirect Property Loss Averted Benefits (Applied Analysis Study in 2023\$.)		\$75.43	\$75.43	\$75.43	\$75.43	\$75.43	\$75.43	\$75.43	\$75.43	\$75.43
Home Appreciation (2.5%)		\$11,000	\$11,275	\$11,557	\$11,846	\$12,142	\$12,445	\$12,757	\$13,076	\$13,402
Insurance Premium Credit		\$73	\$73	\$73	\$73	\$73	\$73	\$73	\$73	\$73
Total Benefits Per Year/ FCF	-\$1,586.90	\$11,148	\$11,423	\$11,705	\$11,994	\$12,290	\$12,594	\$12,905	\$13,224	\$13,551
Cumulative Benefits	\$109,906									
Discount Factors										
Discount Rate	5.25%									
Base Year	2023									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount Factor	1.0000	0.9501	0.9027	0.8577	0.8149	0.7743	0.7356	0.6989	0.6641	0.6310
Discounted FCF	-\$1,587	\$10,592	\$10,312	\$10,040	\$9,774	\$9,516	\$9,265	\$9,020	\$8,782	\$8,550
Cumulative FCF	-\$1,587	\$9,005	\$19,318	\$29,357	\$39,132	\$48,648	\$57,912	\$66,932	\$75,714	\$84,264
NPV	\$84,272									
IRR	705%									

1. Applied Analysis accepted the NIST-developed rationale and associated algorithms, as their report stated: “The analysis contained herein did not attempt to alter the approach or methodology of the National Study, rather apply local fire incident rates and residential fire sprinkler costs.” (As previously stated, while HBM agreed with use of the NIST approach & methodology, it also incorporated actual costs experienced by Clark County fire sprinkler contractors based on their real-world installation of fire sprinkler systems in Las Vegas (NV) homes following the Las Vegas City Council’s mandate that all new home construction of 5,000 square feet or less would require residential fire sprinklers installed.
2. Applied Analysis-developed calculations were based on the “Clark County Averages” for “Fatalities/Injuries/Direct & Indirect Property Damage Averted” due to installation of residential fire sprinkler systems. The Applied Analysis, UNLV, and HBM studies have accepted the NIST assumptions and calculations; however, the Applied Analysis dollar figures were in 2014 dollars. When converted to 2023 dollars = \$75.43 annual savings.
3. HBM Study elected to use lower (actual) insurance premium savings for State of Nevada = \$73 annual savings.
4. HBM Study added the Applied Analysis-developed savings + insurance premium savings to the established home appreciation calculations from Attachment 2 to derive the above cost savings.



Final Report

RESIDENTIAL FIRE SPRINKLER COST BENEFITS DEPICTED GRAPHICALLY
HOME APPRECIATION + NIST-DERIVED DATA
(Depicted Graphically)





Final Report

Nevada Revised Statute (NRS) 237.090

Consideration of a business impact at hearing conducted to adopt proposed rule required.

1. A business impact statement prepared pursuant to NRS 237.080 must be considered at any hearing conducted to adopt a proposed rule and set forth the following information:

(a) A description of the manner in which comment was solicited from affected businesses, a summary of their response and an explanation of the manner in which other interested persons may obtain a copy of the summary.

(b) The estimated economic effect of the proposed rule on the businesses which it is to regulate, including, without limitation:

(1) Both adverse and beneficial effects; and

(2) Both direct and indirect effects.

(c) A description of the methods that the governing body of the local government or its designee considered to reduce the impact of the proposed rule on businesses and a statement regarding whether the governing body or its designee actually used any of those methods.

(d) The estimated cost to the local government for enforcement of the proposed rule.

(e) If the proposed rule provides a new fee or increases an existing fee, the total annual amount the local government expects to collect and the manner in which the money will be used.

(f) If the proposed rule includes provisions which duplicate or are more stringent than federal, state, or local standards regulating the same activity, an explanation of why such duplicative or more stringent provisions are necessary.

2. The governing body of a local government shall not include the adoption of a proposed rule on the agenda for a meeting unless a business impact statement has been prepared and is available for public inspection at the time the agenda is first posted.

(Added to NRS by 1999, 2073; A 2005, 1479)



Final Report
Attachment 6

Nevada Revised Statute (NRS) 202.580

Removal, damage or destruction of signal or apparatus for police or fire alarm; impairing effectiveness of or installing inoperable system for fire protection.

1. Every person who willfully and maliciously removes, damages, or destroys any rope, wire, bell, signal, instrument, or apparatus for the communication of alarms of fire or police calls is guilty of an offense proportionate to the value of the property removed, damaged, or destroyed, but in no event less than a misdemeanor.

2. Every contractor who willfully or maliciously installs or causes to be installed in any structure a fire protection system knowing it to be inoperable, or who impairs the effectiveness of a fire protection system in any structure to an extent that a person in the structure would be endangered in the event of a fire, shall be punished by the permanent revocation of every license issued to the contractor by this state or any political subdivision authorizing the contractor to install fire protection systems, and for a gross misdemeanor.

3. The conviction of a person for a violation of the provisions of subsection 2 does not preclude the prosecution of that person for deceptive trade practices, fraud, or similar crimes.

4. As used in this section:

(a) “Automatic fire extinguishing system” means a system approved by the State Fire Marshal that is installed in a structure and designed to extinguish a specific type of fire. This type of system includes dry chemical, carbon dioxide, halogenated agent, steam, high-expansion foam, foam extinguishing and liquid agent systems.

(b) “Automatic fire sprinkler system” means a system of underground or overhead pipes, or both, to which sprinklers are attached that is installed in a structure and designed to discharge water automatically when activated by heat from a fire and to sound an alarm when the system is in operation.

(c) “Contractor” means any person, including a subcontractor, employee, or agent of the contractor, who, for another person and for compensation or with the intention or expectation of receiving compensation, undertakes to install or cause to be installed, by himself or herself or by or through others, in any structure, a fire protection system.

(d) “Fire alarm system” means a system composed of a control unit and a combination of electrical devices that is designed to sound an alarm in the event of a fire and that may be activated manually, automatically or in both ways.

(e) “Fire protection system” includes an automatic fire sprinkler system, an automatic fire extinguishing system, a fire alarm system, and a standpipe system.

(f) “Standpipe system” means a system of pipes, valves, connectors, and related equipment that is attached to a water supply and designed so that water can be discharged through a hose attached to a connector for the purpose of extinguishing a fire.

(g) “Structure” includes a building, bridge, tunnel, and power plant.

[1911 C&P § 487; RL § 6752; NCL § 10434] — (NRS A [1967, 489](#); [1989, 1044](#))



**Final Report
Attachment 7a**

New Single-Family Dwellings Building Permits Issues (Henderson, Nevada)

Office of Policy Development and Research
US Department of Housing and Urban Development
https://socds.huduser.gov/permits/output_monthly.odb

Housing Unit Building Permits for: HENDERSON, NV Clark County (Preliminary Data)													
	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	July 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total 2016
Units in Single-Family Structures	129	152	215	220	194	283	191	179	199	137	165	159	2,223
	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	June 2017	July 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total 2017
Units in Single-Family Structures	160	188	224	197	275	274	189	187	182	188	207	185	2,456
	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	June 2018	July 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total 2018
Units in Single-Family Structures	243	220	250	275	244	235	228	182	96	150	118	0	2,241
	Jan. 2019	Feb. 2019	Mar. 2019	Apr. 2019	May 2019	June 2019	July 2019	Aug. 2019	Sep. 2019	Oct. 2019	Nov. 2019	Dec. 2019	Total 2019
Units in Single-Family Structures	294	214	184	163	174	196	288	147	156	189	131	178	2,314
	Jan. 2020	Feb. 2020	Mar. 2020	Apr. 2020	May 2020	June 2020	July 2020	Aug. 2020	Sep. 2020	Oct. 2020	Nov. 2020	Dec. 2020	Total 2020
Units in Single-Family Structures	247	231	164	73	103	181	242	178	220	181	128	316	2,264
	Jan. 2021	Feb. 2021	Mar. 2021	Apr. 2021	May 2021	June 2021	July 2021	Aug. 2021	Sep. 2021	Oct. 2021	Nov. 2021	Dec. 2021	Total 2021
Units in Single-Family Structures	324	265	316	346	332	294	200	317	293	173	284	212	3,356
	Jan. 2022	Feb. 2022	Mar. 2022	Apr. 2022	May 2022	June 2022	July 2022	Aug. 2022	Sep. 2022	Oct. 2022	Nov. 2022	Dec. 2022	Total 2022
Units in Single-Family Structures	290	0	0	0	0	0	0	0	0	0	0	0	290



**Final Report
Attachment 7b**

New Single-Family Dwellings Building Permits Issues (Las Vegas, Nevada)

Office of Policy Development and Research
US Department of Housing and Urban Development
https://socds.huduser.gov/permits/output_monthly.odb

Housing Unit Building Permits for: LAS VEGAS, NV Clark County (Preliminary Data)													
	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	July 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total 2016
Units in Single-Family Structures	96	137	145	104	180	161	127	118	94	121	64	107	1,454
	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	June 2017	July 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total 2017
Units in Single-Family Structures	117	83	143	150	167	68	245	105	121	130	89	113	1,531
	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	June 2018	July 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total 2018
Units in Single-Family Structures	109	149	188	165	201	163	135	152	136	162	137	97	1,794
	Jan. 2019	Feb. 2019	Mar. 2019	Apr. 2019	May 2019	June 2019	July 2019	Aug. 2019	Sep. 2019	Oct. 2019	Nov. 2019	Dec. 2019	Total 2019
Units in Single-Family Structures	108	154	174	172	165	142	292	167	120	150	90	151	1,885
	Jan. 2020	Feb. 2020	Mar. 2020	Apr. 2020	May 2020	June 2020	July 2020	Aug. 2020	Sep. 2020	Oct. 2020	Nov. 2020	Dec. 2020	Total 2020
Units in Single-Family Structures	208	186	198	100	81	116	156	138	201	159	144	254	1,941
	Jan. 2021	Feb. 2021	Mar. 2021	Apr. 2021	May 2021	June 2021	July 2021	Aug. 2021	Sep. 2021	Oct. 2021	Nov. 2021	Dec. 2021	Total 2021
Units in Single-Family Structures	187	192	223	240	187	218	105	262	160	271	321	334	2,700
	Jan. 2022	Feb. 2022	Mar. 2022	Apr. 2022	May 2022	June 2022	July 2022	Aug. 2022	Sep. 2022	Oct. 2022	Nov. 2022	Dec. 2022	Total 2022
Units in Single-Family Structures	362	0	0	0	0	0	0	0	0	0	0	0	362



**Final Report
Attachment 7c**

New Single-Family Dwellings Building Permits Issues (Reno, Nevada)

Office of Policy Development and Research
US Department of Housing and Urban Development
https://socds.huduser.gov/permits/output_monthly.odb

Housing Unit Building Permits for: RENO, NV Washoe County (Preliminary Data)													
	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	July 2016	Aug. 2016	Sep. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Total 2016
Units in Single-Family Structures	57	61	108	76	102	80	117	80	149	55	97	77	1,059
	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	June 2017	July 2017	Aug. 2017	Sep. 2017	Oct. 2017	Nov. 2017	Dec. 2017	Total 2017
Units in Single-Family Structures	53	60	115	47	112	112	95	88	101	146	95	100	1,124
	Jan. 2018	Feb. 2018	Mar. 2018	Apr. 2018	May 2018	June 2018	July 2018	Aug. 2018	Sep. 2018	Oct. 2018	Nov. 2018	Dec. 2018	Total 2018
Units in Single-Family Structures	95	133	94	98	110	119	120	116	102	111	143	110	1,351
	Jan. 2019	Feb. 2019	Mar. 2019	Apr. 2019	May 2019	June 2019	July 2019	Aug. 2019	Sep. 2019	Oct. 2019	Nov. 2019	Dec. 2019	Total 2019
Units in Single-Family Structures	77	109	60	58	94	106	124 _i	117 _i	100 _i	120 _i	101 _i	110 _i	1,176
	Jan. 2020	Feb. 2020	Mar. 2020	Apr. 2020	May 2020	June 2020	July 2020	Aug. 2020	Sep. 2020	Oct. 2020	Nov. 2020	Dec. 2020	Total 2020
Units in Single-Family Structures	111 _i	120 _i	116 _i	72 _i	80 _i	111 _i	121 _i	120 _i	126 _i	125 _i	105 _i	123 _i	1,330
	Jan. 2021	Feb. 2021	Mar. 2021	Apr. 2021	May 2021	June 2021	July 2021	Aug. 2021	Sep. 2021	Oct. 2021	Nov. 2021	Dec. 2021	Total 2021
Units in Single-Family Structures	109 _i	116 _i	143 _i	136 _i	119 _i	129 _i	116 _i	124 _i	109 _i	106 _i	102 _i	105 _i	1,414
	Jan. 2022	Feb. 2022	Mar. 2022	Apr. 2022	May 2022	June 2022	July 2022	Aug. 2022	Sep. 2022	Oct. 2022	Nov. 2022	Dec. 2022	Total 2022
Units in Single-Family Structures	113 _i	0	0	0	0	0	0	0	0	0	0	0	113



**Final Report
Attachment 8**

**Nevada Energy Code Collaborative Meeting Minutes
June 22, 2021**

Recording of meeting: <https://vimeo.com/566761972>

Welcome and Introductions!

27 stakeholders joined the second quarter 2021 collaborative online meeting. The focus of this quarters meeting was current outlook and trends in Nevada new construction, state update to the 2021 IECC with non-mandatory appendices and highlights of significant changes between the 2021 IECC and the 2018 IECC for both residential and commercial construction.

State and Local Outlook, Trends and Policies in Nevada (Minute 1:15 in the video recording)

Matt Walker, Greenberg Traurig, and Nat Hodgson SNHBA discussed local and state trends in Nevada. Matt highlighted activity from this year's legislative session in Nevada. SB303 – Solar PV systems, AB 383 – Gas appliance standards, AB452 GHG emission report, AB453 C PACE allows water conservation, SB150 – Tiny Homes, SB448 which among other things increases EV infrastructure in the state, SB442 – Sunsets the Green Building Tax Abatement Program administered by the Governor's Office of Energy. Additional areas the homebuilders are participating is the activity in Clark County with reductions in GHG. It was mentioned that local governments appear to be taking the lead ahead of the state.

Nat Hodgson, SNHBA, mentioned the ongoing hangover from COVID, but this is the strongest year in housing in the Valley since 2007. Processing time for permits has moved from one hour to two weeks. A need for builders is the labor market. Some builders have intentionally slowed down because of the labor issues. It was mentioned that strong migration from California into Nevada continues with 50 pct of buyers in Northern Nevada coming from California, and in Southern Nevada 30 pct of buyers are from California.

Significant Changes to 2021 IECC (Minute 23:00 in the video recording)

Residential – must now declare path of compliance on plans, prescriptive, performance, ERI, and UA tradeoffs. Also, the removal of mandatory requirements in the code now move to mandatory requirements for ERI and performance paths. Insulation increases in CZ 3 and CZ 5 and fenestration/window increased efficiency. Testing is required for air leakage and duct leakage requirements.

Additional efficiency requirements are now included in residential dwellings similar to what has been in commercial facilities since 2015. Also required are clarifications of existing building updates, solar ready and zero energy voluntary appendices.

Commercial – some similar requirements as in residential. Greenhouse updates in code. Insulation requirements increased in code for commercial buildings.

Greenhouse updates are in the code. Insulation requirements increased in code for commercial buildings. Testing is required for air leakage, dwelling, and sleeping unit testing. Air barrier is commissioned. Interlocking operable doors are required in commercial facilities, such as restaurants. Mechanical and Service hot water updates are also required.

Lighting updates and daylighting requirements are new in IECC from ASHRAE 90.1. Energy monitoring and controlled outlets are required, and additional efficiency requirements now have a points-based table for climate zones.



Final Report

DOE determination for residential IECC (1:04 in video recording)

Jim Meyers gave a quick update on the latest DOE residential determination. DOE is mandated to provide an analysis on energy savings from code/standard to the next release. DOE accelerated the analysis this year and shows. DOE estimates national savings of approximately:

CZ3 – Clark County

- 10.48 percent site energy savings
- 9.75 percent source energy savings
- 9.57 percent energy cost savings
- 9.59 percent carbon emissions and social cost of carbon

CZ5 – Washoe County

- 8.50 percent site energy savings
- 7.63 percent source energy savings
- 7.44 percent energy cost savings
- 7.42 percent carbon emissions and social cost of carbon

Carbon emissions and social cost of carbon is new to their determination analysis. States and cities are asking for this information.

DOE residential Nevada field study (1:04 in video recording)

Because of determination work, PNNL is late in performing analysis on the findings in Nevada. We anticipate data from PNNL this summer and a second phase of the study will commence with field and virtual trainings in 2021. ICC Update (1:10 in video recording) Susan Dowty, ICC, discussed recent announcements from ICC. At energy page, www.iccsafe.org/energy. Susan shared the recent ICC announcement of the new standards development committees selected by the ICC board. A mix of builders, government representatives, manufacturers, users, and others have been selected by ICC for the

2024 IECC code/standard.

Robin Yochum with the Governor's Office of Energy is a vice chair for the residential committee. Jim Meyers is also on the committee as is Shaunna Mazingo who presented earlier today on 2021 IECC updates. Building program update and state adoption of 2021 IECC (1:18 in video recording) Robin Yochum, Energy Program Manager, Governor's Office of Energy spoke about updating the state website to include info on 2021 IECC meeting information. The Building energy codes page includes regulation, rulemaking and adoption, and the link to 2021 IECC adoption page.

Wrap Up (1:25 in video recording)

Doodle Poll to help select a date for the next meeting in September/October 2021. Please go to the following link and select dates that work for your schedule:

https://doodle.com/poll/gqmsyugnrccpib8b?utm_source=poll&utm_medium=link



Final Report
Attachment 9

Automatic Residential Fire Sprinkler Systems Value Proposition

“As a fire rages, it transforms and destroys everything in its path. Things inside your home that you'd never consider safe to burn – plastics, insulation, carpet, rubber, paints, solvents, pesticides, glue – release pollutants like PCBs, mercury, lead and dioxins as acrid smoke fills the air and ashy particles rain down. Contaminated water used to fight the fire runs off into storm drains and nearby streams. And all that charred debris? It's likely headed for a landfill.

Of course, there also are carbon emissions from the fire itself (whether it's a forest or a home, burning releases carbon monoxide and carbon dioxide). And if all that weren't enough, fire suppressants used to knock down the flames can contribute contamination, too.”

“The only ‘good’ house fire is one that never happens.”

Pemco Insurance Company
Seattle, Washington

<https://pemco.com/blog/environmental-impact-of-house-fires>

Value to the Community:

- 78% lower overall risk for Fire Fighters and Emergency Medical Personnel. ([Aherns, Marty, US Experience with Sprinklers, October 2021, NFPA](#))
- Quick suppression of fire limits potential spread to other residences.
- The National Fire Prevention Association states that sprinkler systems reduce the amount of water run-off and pollution by as much as 71%. (<https://nfsa.org/benefits-fire-sprinklers/>)
- 60-70% mean reduction of CO2 equivalent GHG emissions being released into atmosphere. (Assessing the Impact of Vegetation and House Fires on Greenhouse Gas Emissions Scion & BRANZ April 2010) (<https://fireandemergency.nz/assets/Documents/Research-and-reports/Report-104-Assessing-the-Impact-of-Vegetation-and-House-Fires-on-Greenhouse-Gas-Emissions.pdf>)

Value to Home Buyer:

- Safety: In 2018, there were 2,360 deaths and 7,800 injuries due to house fires in single- and two-family homes. (<https://nfsa.org/benefits-fire-sprinklers/>)
- 7 percent of reported home structure fires that occurred in properties with sprinklers accounted for **1 percent of home fire deaths, 5 percent of home fire injuries, and 3 percent of home property loss.** (<https://nfsa.org/benefits-fire-sprinklers/>)
- Safe escape route out of burning home.
- Reduces exposure and inhalation to dangerous chemical combustive by-products.



Final Report

- Fire suppression isolated to smaller area of home, which limits damage to unaffected portions of home.
 - Putting out an average house fire takes between 5 minutes and 2 hours. (<https://lisbdnet.com/how-long-does-it-take-to-put-out-a-fire/>)
 - Average amount of water required to extinguish house fire: 20,000 gallons (<https://www.kiserrenovations.com/>)
 - Average amount of water required by automatic fire sprinkler system: 200 gallons, which is 1% of 20,000 gallons. (“Why Sprinklers” Power Point Presentation by Pat Coughlin)

Value to Home Builder:

- Enhanced reputation for building safer homes.
- Demonstrates strong commitment to protecting the environment.
- No long-term downturn in “New Home Starts” by implementation of residential fire sprinkler ordinances in Henderson, Las Vegas, and Reno, Nevada. (Reference: Attachments 7a, b, and c).
- 74% of U.S. homeowners said they would be more likely to buy a home with fire sprinklers than one without. Seven in 10 said a sprinklered house has more value and nearly 8 in 10 (78%) said fire sprinklers provide the ultimate protection for residents. (<http://www.fireemsleaderpro.org/2015/12/22/residential-fire-sprinkler/>)