ONWARD HISTORIC PRESERVATION! EXPLORING ENVIRONMENTAL IMPACTS OF NEW CONSTRUCTION THROUGH LIFE CYCLE ASSESSMENT (LCA): A POLICY PERSPECTIVE

by

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A TERMINAL PROJECT

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TERMINAL PROJECT APPROVAL PAGE

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This terminal project has been accepted and approved in partial fulfillment of the requirements for the Master of Science degree in the Historic Preservation program by:

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Preface

The initial motivation for this project was the desire to root academic research and knowledge in practical application. After living in Portland, Oregon for ten years I began to witness the destruction of historic resources in the inner Southeast Hosford - Abernethy neighborhood. Before this experience of demolitions, I was sheltered from the destruction of old buildings. I learned to appreciate the musty smell of an old basement and peeling paint at an early age. Growing up in Northampton, Massachusetts I was privileged to be protected from the devastation of demolition. Many years later after moving to Portland I fell in love with old buildings all over again. I began to question the contradiction between the city's touted progressive policies and the destruction of existing buildings without consideration of the environmental impact. This project is an attempt to answer this long-held question; using scholarship to move from conceptual understanding to solidifying observations and experience through production of measurable impacts.

Overview

The focus of this terminal project is to research and measure the environmental impact of demolitions of single-family homes in Portland through the lens of Life Cycle Assessment (LCA). LCA is a method of estimating the life cycle impacts of a product, including the various processes used to process, manufacture, use and dispose of an item – in this context an entire building. This experiment is intended to create a standardized measurement of the carbon footprint that occurs as a result of demolition and associated new construction. The specific application is the approximately 400 demolitions of existing buildings that occurred in Portland, 2015 – 70% of which were single family homes[1] and the approximately 100 new single family homes that were built to replace them. According to the National Trust for Historic Preservation Green Lab's report, *The Greenest Building: Quantifying the Environmental Value of Building Reuse*, "additional research and analysis [is] needed to help communities design and employ public-policy tools that will remove obstacles to building reuse.[2]" Research conducted to inform policy has the potential to be a helpful tool for more effective preservation planning and advocacy. Data analysis and synthesis of accumulated data will yield results that will build upon existing knowledge, including several historic preservation case studies that utilize Life Cycle Assessment to assess carbon impacts of new construction. It is important to mention that the socio-cultural element of demolishing existing buildings is worthy of its own study. However, the scope of this work focuses on the connections between land use policies, carbon reduction and reuse of existing buildings. This

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[1] This number is based on original research conducted by the author.

[2] Preservation Green Lab, National Trust for Historic Preservation, *The Greenest Building: Quantifying the Environmental Value of Building Reuse*, p VIII, 2011.

research has the potential to influence policy decisions that will shape the sustainability of cities now and in the future, especially in the face of balancing pressures of development and reduction of carbon impacts.

Problem Statement

It is widely agreed that global warming and climate change are some of the biggest environmental challenges of the 21st century. Global organizations including the Intergovernmental Panel on Climate Change (IPCC), a group of scientists and policy makers who analyze climate change science and make recommendations,[3] have agreed that anthropogenic activities which generate heat trapping greenhouse gases are the primary cause of global warming.[4] At the local level, individual cities are mobilizing to reduce greenhouse gas emissions through creation of policies that promote buildings with low operational and material impacts relative to greenhouse gases. In Portland, Oregon, a city rich with a stock of existing buildings, approximately 400 existing buildings were demolished in 2015, 70% of which were wood framed single-family homes.[5]

In the context of Portland's policies to combat climate change at the local level, lack of information about carbon emission related impacts of demolitions and new construction is problematic. Data created from life cycle assessment impact analysis of new single-family homes that replace demolished existing single-family homes offers baseline information about the carbon footprint of new construction, which could inform current carbon reduction goals.

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[3] Intergovernmental Panel on Climate Change (IPCC), *Introduction,* December 2004,

[4] Le Treut, H., R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson and M. Prather, *2007: Historical Overview of Climate Change*. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA), Chapter,Table 9.4.

[5] These figures are based on research of demolition permits issued in 2015 by the City of Portland Bureau of Development Services.

Project Goals

It is important to clarify specific intentions which guide this body of work. This terminal graduate project serves the purpose of three goals:

1) Learn how to use Life Cycle Assessment (LCA) to estimate the impacts of new construction. Explore the intersection of LCA and historic preservation.
2) Discuss Oregon land use policies, including management of existing buildings within the City of Portland's Historic Preservation Plan, The Comprehensive Plan and Climate Action Plan guide. Recommend potential policy adjustments based on original research and existing case studies that utilize LCA as a tool to advocate for reuse.
3) Assess the environmental value of new single-family residences using the Sellwood - Moreland neighborhood case study. Build on the findings of Preservation Green Lab report, "The Greenest Building: Quantifying the Environmental Value of Reuse" which suggest that rehabilitation and reuse of existing buildings in Portland would help Portland meet its carbon reduction goals.

Research Methods

Primary to the research methodology of this terminal project is analysis of Oregon's historic land use laws, Portland land use regulations, including historic preservation policies as well as review of demolition permits. The policy analysis included a review of the Portland Comprehensive Plan, Carbon Action Plan and the Oregon Land Conservation and Development Act of 1973 (SB100), Oregon's seminal comprehensive planning legislation. I researched specific areas of overlap within these policies regarding management of existing buildings and historic resources; carbon reduction and demolitions in Portland. Demolition permits issued in 2015 by the City of Portland Bureau of Development Services were assessed for date of permit issue, address, building type. Additional information provided with demolition permits were also considered including drawings of existing buildings and plans for the new construction. Permits were organized by zip code to determine the neighborhood where the most demolitions occurred and from which the case study property was selected. Life Cycle Assessment modeling software Athena Impact Estimator v. 5 was utilized to process the impacts of new single-family home construction, the specific methodology of which is outlined in Chapter V Sellwood: A Case Study Using LCA.

In the context of these environmental-based policies the impetus is to identify how the issue of demolition of existing buildings undermines the very goals of attaining a lighter environmental footprint. This issue is especially poignant when houses are demolished without a measurement of environmental impacts. Life Cycle Assessment (LCA) was chosen to make the seemingly "invisible" impacts visible through an avoided impacts approach which analyzes the environmental impacts associated with new construction. Speaking the same language of professions closely related to the field of historic preservation is essential to strengthening relationships and working together towards a more sustainable future.

Chapter II: Policy Context

Senate Bill 100: Thoughtful Land Use Planning

Oregon is known for its progressive land use planning policies. In 1973 Governor Tom McCall signed into law Senate Bill (SB) 100, a state-wide land use law which prioritized the natural environment including protection of forest and farm land from development. SB 100 created the Oregon Land Conservation and Development Commission, in charge of carrying out the state law. The law was meant to protect livability and promote a high quality of life through state and local long term land use planning. Principles of SB 100 include:

> (A) Provide a healthy environment;
> (B) Sustain a prosperous economy;
> (C) Ensure a desirable quality of life; and
> (D) Equitably allocate the benefits and burdens of land use planning.
> (b) Additionally, the land use program should, but is not required to, help communities achieve sustainable development patterns and manage the effects of climate change."[6]

This statewide planning law directed land use at the local level by mandating comprehensive planning. SB 100 defines a comprehensive plan as, "a generalized, coordinated land use map and policy statement of the governing body of a local government that interrelates all functional and natural systems."[7] Included in the 1973 legislation was a mechanism to contain sprawl called the Urban Growth Boundary, "a

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[6]Oregon Revised Statutes, *Vol. 5 State Government, Government Procedures, Land Use 197.010 (2)* in OregonLaws.org, accessed May 2016, http://www.oregonlaws.org/ors/197.010.

[7] Oregon Revised Statutes, *Vol. 5 State Government, Government Procedures, Land Use Chapter 197 Comprehensive Land Use Planning I,* accessed May 2016, https://www.oregonlaws.org/ors/197.015.

land use planning line to control urban expansion onto farm and forest lands."[8] Metro is a directly elected regional planning agency that covers Washington, Clackamas and Multnomah counties, including 24 cities. This agency controls the growth of this boundary and manages long term development.[9] Every 6 years Metro publishes an "Urban Growth Report" to determine whether to expand the Urban Growth boundary. The report considers whether the existing available land inside the boundary can accommodate projected housing needs and employment growth for the next 20 years.[10] Last year in 2015 Metro chose not to expand the boundaries, concluding that enough land exists within the UGB to serve the needs of the growing Portland region.

Population growth in the Portland regional area is a complex and multilayered issue that affects management of existing buildings in a number of different ways. According to Metro an additional 400,000 people will live in Portland region between 2015 and 2035.[11] In order to meet the increase in population, redevelopment and infill provide needed development including housing and other amenities. Redevelopment is defined as, "development on a tax lot where the original structure has been demolished and there is a net increase in housing units."[12] Infill is, "development on a tax lot where the original structure has been left intact and the lot is considered developed."[13] In the context of historic preservation, redevelopment has the most potential to adversely affect

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[8] Metro, *Urban Growth Boundary: Overview*, accessed May 2016 http://www.oregonmetro.gov/urban-growth-boundary.
[9]Metro, *What is Metro?*, accessed May 2016, http://www.oregonmetro.gov/regional-leadership/what-metro
[10]Metro, *2014 Urban Growth Boundary Report*, accessed November 2015, http://www.oregonmetro.gov/urban-growth-report.
[11] Metro, *Metro Guide 2015 Growth Management Decision,* accessed November 2015, http://www.oregonmetro.gov/sites/default/files/Growth-management-factsheet-20160115.pdf, 2.
[12]Metro, *2014 Urban Growth Boundary* Report: Revised Draft, accessed November 2015, http://www.oregonmetro.gov/sites/default/files/2014-urban-growth-report-Revised-Draft-FINAL.pdf, 7.
[13]Ibid.

historic existing buildings and neighborhoods as it often involves demolition and replacement of existing residential and commercial buildings.

The City of Portland's Comprehensive Plan is a strategy to manage change and provide a vision of the city's growth for the next 20 years. Challenges facing the city in addition to anticipated population growth include housing, transportation, infrastructure, equity, jobs and the myriad impacts of a changing climate. Within the Portland 2035 Comprehensive Plan there are goals and objectives for climate change and protection of historic resources. In Chapter 7, "Environment & Watershed Health," Goal 7.A *Climate* has a goal of reducing carbon emissions by 50 percent below 1990 levels by 2035. Connection between the built environment and climate, is stated in Goal 7.C: *Resilience*: "Portland's built and natural environments function in complementary ways and are resilient in the face of climate change and natural hazards." Carbon reductions in the built environment are more specifically defined in Chapter 4: "Design and Development," which includes a goal to, "reduce carbon emissions and promote energy and resource efficient neighborhoods and buildings."[14] Under "Residential Areas" of chapter 4:

> Policy 4.17 Demolitions. Encourage alternatives to the demolition of sound housing, such as rehabilitation and adaptive reuse, especially affordable housing, and when new development would provide no additional housing opportunities beyond replacement.
>
> Policy 4.18 Compact single-family options. Encourage development and preservation of small resource-efficient and affordable single-family homes in all areas of the city.[15]

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[14] Ibid.

[15] City of Portland, *2035 Comprehensive Plan - Chapter 4: Design Development*, GP4-7.

Demolitions are also included in the Historic and Cultural Resources section of Design and Development chapter. This is important because the specific language used indicates a concern about the appropriate destruction of a historic resource:

> Policy 4.50 Demolition. Protect historic resources from demolition. When demolition is necessary or appropriate, provide opportunities for public comment and encourage pursuit of alternatives to demolition or other actions that mitigate for the loss.[16]
>
> Policy 4.60 Rehabilitation and adaptive reuse. Encourage rehabilitation and adaptive reuse of buildings, especially those of historic or cultural significance, to conserve natural resources, reduce waste, and demonstrate stewardship of the built environment.[17]

One way that the Comprehensive Plan executes its development plan is through zoning change management. While planning and zoning regulations coordinated with preservation ordinances and designation offer the strongest preservation protections, they can also be the most destructive, "zoning laws can either encourage or undermine preservation activities."[18] In Portland changes in zoning are managed through the Bureau of Development Services (BDS) which also manages permitting for property use, including demolitions. According to BDS, "The Portland Zoning Code (Title 33) is intended to implement Portland's Comprehensive (or long-range) Plan and related land use plans in a manner that protects the health, safety and general welfare of the citizens of Portland."[19] Zoning regulations are applied to neighborhoods depending on their location and the projected use of an area. Zoning changes that support demolition of existing structures occur when more dense development becomes a priority. However, zoning intended to increase population density is not always the cause of demolitions as we see

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[16] Ibid., GP4-12.
[17] Ibid., GP4-13.
[18] Robert E. Stipe, *A Richer Heritage*, The University of North Carolina Press, 2003, 167.
[19] City of Portland, Bureau of Development Services, *Overview of the Zoning Code*, accessed November 2015, https://www.portlandoregon.gov/bds/article/411725.

later in the case study of a single family demolished in a R5 Zone, Single Dwelling Zone. Under Tile 33, the purpose of a Single Dwelling Zone is, "to preserve land for housing and to provide housing opportunities for individual households. The zones implement the comprehensive plan policies and designations for single-dwelling housing."[20] In this context single family homes can be demolished and replaced with other single family homes. Demolishing existing single-family homes, including those that have been identified as important historic resources has both socio-cultural and environmental implications. From a carbon impacts perspective, the embodied energy in both the existing single-family home and the larger new single-family home construction though not readily apparent occur throughout the buildings' life cycle, creating a carbon debt that has not been calculated. It is therefore questionable whether this type of development is benefitting the larger community.

Demolitions of Existing Buildings in Portland

The City of Portland is robust with a diverse building stock, both designated historically significant at the local and national level as well as historic (over 50 years old) but not identified as significant. The former buildings are those that fall in the category of vernacular architecture or "commonplace architecture…individual buildings, [and] assemblages of such buildings."[21] In the context of a city that is experiencing rapid population growth and development pressures, management of historic resources is challenging and controversial. The City of Portland's historic preservation program

[20] City of Portland, *Title 33 Planning and Zoning*, Chapter 33.110, 110-1.
[21] Thomas Carter and Elizabeth Collins Cromley, Invitation to Vernacular Architecture: A Guide to the Study of Ordinary Buildings and Landscapes. (Knoxville: The University of Tennessee Press, 2005), xiv.

which operates from the Bureau of Planning and Sustainability, helps individuals and organizations to identify, and protect historic resource. The program uses a variety of land use planning tools including Historic Resource Overlay Zones and Conservation Districts as well as National Register of Historic Places Districts to protect these resources. Management of existing buildings, including incentives for preserving historic resources are also outlined in Title 33, Planning and Zoning, Chapter 33.445 *Historic Resource Overlay Zone*. The goal of Title 33 is to, "increase the potential for historic resources to be used, protected, renovated and preserved. Incentives make preservation more attractive to owners of historic resources because they provide flexibility and economic and opportunities."[22]

Demolition delays offer a type of short term protection for buildings that are in immediate endanger of being destroyed. The process of demolitions, from issuing of permits to issuing demolition delays is managed by the Bureau of Development Services (BDS). Recent regulation that was passed in Portland mandates a demolition day of 35 days for single family residential buildings that are in zoned R for residential with the exception of homes located in commercial zones. For those buildings listed in the Historic Resources Inventory, a delay of 120 days applies.[23] Demolition delays are "intended to allow an adequate amount of time to help save viable housing in the City while recognizing a property owner's right to develop or redevelop property."[24] Historically demolition ordinances were implemented to give time for buildings to be

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[22] City of Portland, *Title 33, Planning and* Zoning Chapter 33.445 Historic Resource Overlay Zone, 33.445.610 "Historic Preservation Incentives", 445.

[23] City of Portland Bureau of Development Services, *UPDATED September 12, 2016: Historic Resource Inventory (HRI) Buildings and Demolition Delay Policy Effective September 1, 2016,* accessed November 2016, http://www.portlandoregon.gov/bds/article/588352.

[24] Ibid.

rehabbed and brought up to code.[25] The recent ordinance was a result of concern from the community about demolishing single family homes that are in good conditions and are being demolished in preparation for redevelopment. There is an opportunity to build on Oregon's progressive land use and conservation ethic, including concerns for carbon emissions by looking at existing buildings as having environmental value.

Portland's Commitment to Reducing Carbon Emissions

Discussion about the role of climate change in state land use planning laws began in 1988 with the Oregon Task Force on Global Warming created by Governor Goldschmidt and included twelve state agencies. The goal of the task force was to analyze the scientific data about global climate change and determine how it would affect Oregon. The report issued to Goldschmidt found that, "climate change from global warming is a serious threat" and "Oregonians can insure themselves against some of the changes by taking prudent actions to slow the emissions of greenhouse gases and by planning to adapt to changes."[26] The report made it clear that Oregon had a responsibility to reduce its global warming impact and prepare itself for the ramifications of climate change by utilizing state land use planning framework at the local and state level.

The state's move towards reduction of greenhouse gases became part of forward thinking environmental land use policy began in 1989 with ORS 468A.205 Policy; greenhouse gas emissions reduction goals,

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[25] City of Portland, Bureau of Development Services, *Demolition Delay Ordinance and Exception to Delay Notification When Applicant Simultaneously Applies for a Building Permit for a Replacement Residence*, Accessed December 2016, https://www.portlandoregon.gov/bds/article/494371.
[26] Oregon Department of Energy, *Oregon Task Force on Global Warming Report to the Governor and Legislature*, June 1990.

(1) The Legislative Assembly declares that it is the policy of this state to reduce greenhouse gas emissions in Oregon pursuant to the following greenhouse gas emissions reduction goals: (a) By 2010, arrest the growth of Oregon's greenhouse gas emissions and begin to reduce greenhouse gas emissions. (b) By 2020, achieve greenhouse gas levels that are 10 percent below 1990 levels. (c) By 2050, achieve greenhouse gas levels that are at least 75 percent below 1990 levels.[27]

Portland has lowered its carbon emissions by 14% below 1990 levels – 35% percent per person.[28] At the local level, Portland became the first city in the U.S. in 1993 when it set carbon dioxide reduction goals Portland's 1993 CO2 reduction strategy established a reduction target of 20 percent below 1990 emissions by 2010. The current iteration of these efforts is found in the 2015 Climate Action Plan.

The 2015 Action Plan contains eight categories that contain specific objectives and goals to meet the reduction of 80% reduction of 1990 levels by 2050 with an interim goal of 40% by 2030. Within these eight categories there is little mention about the environmental benefit of historic resource use. In the Consumption and Solid Waste category, adaptive reuse and rehabilitation is one of the objectives to be accomplished by 2020:

> "8E Rehabilitation and Adaptive Reuse — Promote rehabilitation, adaptive reuse and energy and seismic upgrades of buildings to conserve natural and historic resources, reduce waste and improve public safety."[29]

The focus of this category is the upstream reduction of carbon emissions and it is here where carbon emissions and reuse are clearly connected. Reduction of carbon emissions associated with energy use through improvements of energy efficiency and "reducing the

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[27] 2015 Oregon Revised Statutes, Vol. 10 Highways, Military, Juvenile Code, Human Services, Chapter 468A, Air Quality, Policy, *Greenhouse gas emission reduction goals*, accessed November 2016 https://www.oregonlaws.org/ors/468A.205.
[28] City of Portland Bureau of Planning and Sustainability, "Portland City Council Adopts New Climate Action Plan," Accessed December 2106, http://www.portlandoregon.gov/bps/article/535638?.
[29] City of Portland and Multnomah County, *2015 Climate Action Plan*, 90.

carbon intensity of energy supplies" is focused with the Buildings and Energy category. This category has some focus on reuse but is largely focused on new construction. Three objectives to be accomplished by 2030 include the following established goals and intentions:

1. Reduce the total energy use of all buildings built before 2010 by 25 percent.
2. Achieve zero net greenhouse gas emissions in all new buildings and homes.
3. Supply 50 percent of all energy used in buildings from renewable resources, with 10 percent produced within Multnomah County from on-site renewable sources, such as solar.

Smaller steps to accomplish these goals vary from energy ratings system for commercial buildings to building markets for construction of net zero buildings. Objective 2 reflects the concept that new construction with advanced energy efficiency is one way to move toward carbon reductions:

"The best time to begin addressing building efficiency is in the initial building design stage. Buildings that have been designed and built with performance as a primary goal are capable of significantly outperforming similar, previously built buildings that have been retrofitted for efficiency."[30]

Emphasis on the design stage of building to reduce carbon emissions of new construction is typical of green building design because it offers more control over application of specific technologies and avoids the need to consider the existing building envelope.

Integrative approaches that explore the potential of existing buildings to further carbon reduction goals is one way to build upon a legacy of thoughtful land use planning laws. The conservation ethic inherent within comprehensive planning combined with an impetus to reduce current carbon impacts offer a new way to approach historic preservation policy. For example, within the "Buildings and Energy" of the Carbon

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[30] The City of Portland and Multnomah County, *June 2015 Climate Action Plan Local Strategies to Address Climate Change, Buildings & Energy*, 66.

Action Plan it is recognized that "policy choices affect carbon emissions"[31] listing a group of partnerships with public agencies, businesses and organizations including Energy Trust of Oregon, Earth Advantage, PGE, Northwest Energy Efficiency Alliance and Oregon Department of Energy to further energy efficiency and renewable energy. Integration with local preservation organizations such as the Architectural Heritage Center or Restore Oregon with these organizations has the potential to facilitate a collaborative discourse regarding the benefits of reuse, including life cycle assessment.

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[31] Ibid., 59.

Chapter III: A Brief History of Sustainable Preservation

Environmentalism & Historic Preservation: Historical Overview

The building and construction industry have long been associated with having a large environmental footprint. Historic Preservation provides a way to mitigate these impacts, including reduction of carbon emissions through reuse. According to the IPCC, "as buildings are very long-lived and a large proportion of the total building stock existing today will still exist in 2050 in developed countries, retrofitting the existing stock is key to a low-emission building sector."[32] In regards to energy conservation the preservation field has historically focused on benefits of retaining the embodied energy of old buildings. In the 1970's during the oil embargo America had energy conservation on its mind – before the concerns of climate change were well established. Sustainable Preservation today is inclusive of the overlapping areas of sustainability and historic preservation. In her book "Sustainable Preservation", Preservation Architect Jean Carroon points out the "need for immediate action to address climate change and the related environmental degradation is increasingly urgent, and the major role that the building industry must take in abating the crisis is unequivocal."[33] The shift toward

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[32] Lucon O., D. Ürge-Vorsatz, A. Zain Ahmed, H. Akbari, P. Bertoldi, L.F. Cabeza, N. Eyre, A. Gadgil, L.D.D. Harvey, Y. Jiang, E. Liphoto, S. Mirasgedis, S. Murakami, J. Parikh, C. Pyke, and M.V. Vilariño, 2014: Buildings. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA., p 690.

[33] Jean Carroon and Richard Moe, *Sustainable Preservation: Greening Existing Buildings* (Hoboken: Wiley, 2010), 3.

utilization of common environmental assessment tools is one way that historic preservation can work towards collaborative climate change solutions.

Historic preservation and sustainability include many areas of overlapping concern. Looking at the timeline of historic preservation and sustainability presented in University of Pennsylvania Historic Preservation Graduate Erika Leigh Hasenfus's thesis, *Measuring the Energy Capital Value in Historic Structures*, we can see how important dates of the two fields intersected (Figure 1). The historic preservation evolution timeline begins with National Historic Preservation Act (NHPA) in 1966, in the same decade that Rachel Carson's *Silent Spring* was published. In 1979 [34] the Advisory Committee on Historic Preservation (ACHP) was put out at the same time of the second oil crisis and is based on the earlier study put out by the 1976 report *Energy Use for Building Construction* completed by the University of Illinois. In his article "Embodied Energy and Historic Preservation: A Needed Reassessment," Mike Jackson discusses the importance of this study and some of its limitations, "one of the most useful aspects of the report is a summary of the typical embodied-energy values for various building types presented in MBtu/sq. ft."[35] He also discusses how the report may have underestimated the embodied energy of historic buildings due to the fact that they had, "more volume and greater amounts of materials."[36] The term "embodied energy" began to be used by the preservation community to represent the accumulated energy that was locked up in old buildings. One of the pioneers who developed embodied energy, Bruce Hannon, initially began his study of embodied energy for a diverse range of products from beverage cans

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[34]Erika Leigh Hasenfus, *Measuring the Capital Energy Value in Historic Structures, Master's Thesis,* (University of Pennsylvania, Philadelphia, PA, 2013), 24.
[35]Mike Jackson, "Embodied Energy and Historic Preservation: A Needed Reassessment," APT Bulletin, Vol. 36, no. 4 (2005): 47.
[36]Ibid.

to goods and services; determining the embodied energy costs of "the entire amount of energy and of labor of every type that had to be extracted because of the existence of this unit." Hannon then partnered with a New York architect to study how embodied energy could be applied to existing and remodeled buildings. As the concerns of global warming increased so has sustainability related efforts to mitigate climate change. Historic Preservation has mirrored those efforts, most notably with the Preservation Green Lab's life cycle approach to building reuse.

Historic Preservation & Sustainability

A Timeline

Sustainability Evolution	Historic Preservation Evolution
1962: *Silent Spring*, Rachel Carson	**1966:** National Historic Preservation Act
1970: First Earth Day Environmental Protection Agency Formed	**1971:** Executive Order for the Protection and Enhancement of the Cultural Environment
1972: *The Limits to Growth*, Club of Rome Report	**1978:** Preservation Briefs 3 – *Conserving Energy in Historic Buildings*
1973: OPEC oil embargo	**1979:** Advisory Council on Historic Preservation report released
1974: Federal Energy Administration Act signed	**1981:** *New Energy from Old Buildings*
1977: The Department of Energy Organization Act signed	**1994:** *Guiding Principles for Sustainable Design*, The National Park Service
1979: Second oil crisis begins, Iranian Revolution	**1998:** *Sustainable Design and Historic Preservation*, Sharon C. Park
1987: *Our Common Future*, Brundtland Commission report	**2004:** Association of Preservation Technology formed Technical Committee on Sustainable Preservation
1993: U.S. Green Building Council established	**2009:** Preservation Green Lab formed, The National Trust for Historic Preservation
1997: The Kyoto Protocol	**2012:** *The Greenest Building: Quantifying the Environmental Value of Building Reuse* published
2002: UN World Summit on Sustainable Development	
2007: Intergovernmental Panel on Climate Change Fourth Assessment Report	
2013: President Obama commits U.S. to 17% reduction below 2005 greenhouse gas emissions levels by 2020	

Figure 1. Timeline of sustainability and historic preservation.

In 2016 the term embodied energy is still relevant to the construction and design field. However, due to major climate change, changing weather patterns, resource depletion and a myriad of environmental concerns, the context of embodied energy has changed since the 1970's. What has changed over the years is the acceptance of climate change science and the consensus that greenhouse gases emitted by a variety of human activities are causing the earth's surface to heat up. Carbon related impacts is currently a language common to designers, architects and construction professionals and therefore is a type "currency" that could be better utilized by the preservation field. Life Cycle Assessment is part of this currency and one that the preservation field might better learn in order to collaborate and work toward a common goal of sustainable development.[37]

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[37]Erika Leigh Hasenfus, *Measuring the Capital Energy Value in Historic Structures*, Master's Thesis, (University of Pennsylvania, Philadelphia, PA, 2013), 3.

Chapter IV: Life Cycle Assessment (LCA)

Development & Application

One way to determine the varied impacts that occur over a product's life cycle is Life Cycle Assessment (LCA). LCA is a tool to understand "product systems rather than the material product we may use and the service we may hire."[38] This system is based on a flow of inputs – the resources and energy that go into a product's life, including the sourcing and processing of materials, product production and eventual demise of the product, including demolition and disposal. Each step in the process has an impact, these outputs which are measured by LCA modeling which measures impacts on the environment, human health and resources. These areas of impact are referred to as "impact categories"[39] and generally include global warming potential, eutrophication potential, acidification, primary energy, ozone depletion, smog, non-renewable energy consumption, and human health particulates. The International Standards & Organization 14040 created a framework for LCA in the design and construction process; use and maintenance; and demolition/deconstruction phase.

Over the past 50 years, the Life Cycle Assessment (LCA) methodology has had a dramatic progression from primarily private industry driven use to a broader public engagement, including application to the built environment. The systems based approach

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[38] Walter Klopf, *Background and Future Prospects in Life Cycle Assessment,* (Springer Netherlands, 2014), 3.

[39] American Institute of Architects (AIA), *Guide to Building Life Cycle Assessment in Practice* (Washington, DC: The American Institute of Architects, 2010), 17.

first began in the 1960's as a way to measure the environmental impacts of products with an emphasis on resource conservation and energy saving.[40]

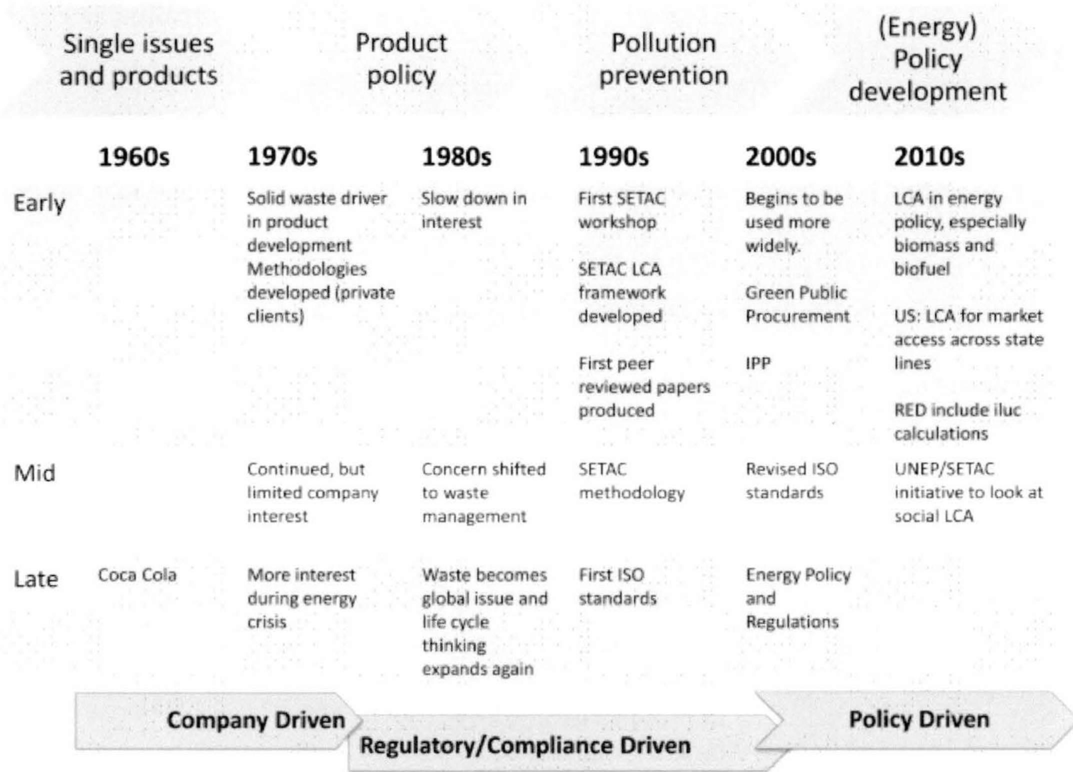

Figure 2. Timeline of Life Cycle Assessment Development.[41]

The first application of LCA took place for Coca Cola and was used for measuring associated environmental impacts of different beverage containers. This initial LCA included similar parameters used to assess the built environment today – it was what Klopff referred to as "proto-LCA".[42] The proto LCA was focused more on life cycle inventory whereas the modern LCA that is used today is more rooted in the quantitative analysis of measured impacts assigned to specific processes.

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[40] Walter Klopf, *Background and Future Prospects in Life Cycle Assessment*, (Springer Netherlands, 2014), 1.
[41] Marcelle C. McManus and Caroline M. Taylor, "The changing nature of life cycle assessment," *Biomass & Bioenergy*, (2015): 15.
[42] Ibid.

The early 1970s presented a context of parallel developments in energy and resource conservation within both historic preservation and product improvement scientists that today are directly aligned. One of the LCA's original incarnation was the Resource and Energy Profile Analysis (REPA) conducted by Franklin Associates, a consulting group that conducted its first assessment for Coca-Cola.[43] REPA evolved into LCA in the early 1990's during a workshop of Society of Environmental Toxicology and Chemistry (SETAC) called, *Guidelines for Life-Cycle Assessment: A Code of Practice*. SETAC was instrumental to pushing the development of LCA from an organizational standard.

In the late 1960's the U.S. government funded studies of energy use and conservation, including analysis of the construction industry. Published in 1977 a report called the *Energy Use for Building Construction* was prepared for the U.S. Energy Research and Development Administration under the Energy Research Group Center for Advanced Computation at the University of Illinois at Urbana-Champaign. The report was an early life cycle inventory - looking at 49 building materials and embodied energy of each material. While not directly related at the time the areas of LCA and Historic Preservation evolved as a response to the environmental concerns which arose from increased awareness about the balance of human activity and the health of the environment.

Today LCA is et exclusive to consumer products and includes buildings. This project focuses on the use of Life Cycle Assessment for whole buildings. In her book, "Life Cycle Assessment," Kathrina Simonen discusses that the level of data accumulation

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[43] Walter Klopf, *Background and Future Prospects in Life Cycle Assessment*, (Springer Netherlands, 2014), 5.

depends on the goal and objective of a LCA. She notes that, "the LCA scope should support the goals of the LCA."[44] Using the ISO standards as a launching point which include four elements: *the product to be studied (functional unit); the system boundary (what processes are included in the study); methodological choices (and analysis details.*[45] In the context of this study the products are both the historic existing buildings as well as the new construction. The declared unit are the building assemblies, the foundation, interior and exterior walls, roof, floors, windows, etc. The functional unit is the purpose of the material; how it performs and duration.

LCA Relevance to Architecture / Avoided Impacts

The term "avoided impacts" is used in the of sustainable design of the built environment, it refers to mitigation of "negative actions such as replacement."[46] In the context of historic preservation avoided impacts is an approach to determine what impacts can be avoided by forgoing new construction and reusing existing buildings.

US Life Cycle Inventory (LCI) Database

Life Cycle Inventory (LCI) data is integral to the process of LCA as it provides the metrics associated with material use, energy and emissions that are associated with specific products.[47] The type of inventory depends on the modeling software that is used, for the purpose of this case study the Athena Impact Estimator was used. The Athena

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[44]Kathrina Simonen, *Life Cycle Assessment,* (Routledge: New York, 2014), 18.
[45]Ibid., 18.
[46]Jean Carroon and Richard Moe, *Sustainable Preservation: Greening Existing Buildings,* (Hoboken: Wiley, 2010), 261.
[47]American Institute of Architects (AIA), Guide to Building Life Cycle Assessment in Practice (Washington, DC: The American Institute of Architects, 2010), 18.

Institute develops its own inventory database which includes products as well as construction information related to building assemblies. The Impact Estimator is built specifically for whole building analysis therefore the metrics associated with, "a collection of assemblies."[48]

Historic Preservation and Life Cycle Assessment (LCA) Case Studies

The Greenest Building: Quantifying the Environmental Value of Building Reuse. A Report by Preservation Green Lab, National Trust for Historic Preservation

The body of knowledge regarding measurement of environmental benefits associated with historic building reuse in the United States through Life Cycle Assessment is limited. The most complete and often cited LCA for older buildings is *The Greenest Building: Quantifying the Environmental Value of Building Reuse* published in 2011 by The National Trust for Historic Preservation Green Lab. The research objectives for *The Greenest Building* focused on comparing the "life cycle environmental impacts"[49] of existing building renovation as compared to new construction; determination of which stage a building has the most impacts and understanding how during a building's life cycle "building typology, geography, energy performance,

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[48]Athena Sustainable Materials Institute, *User Manual and Transparent Document: Impact Estimator for Buildings v. 5, (September, 2014)*, 19.
[49]Preservation Green Lab, National Trust for Historic Preservation, *The Greenest Building: Quantifying the Environmental Value of Building Reuse*, (2011), 26.

electricity-grid mix, and life span on environmental"[50] affect the environment. The study looks at existing buildings in Chicago, Atlanta, Phoenix and Portland.

The *Greenest Building* report looks at six different building typologies, single-family residential, multifamily residential, commercial office, urban village mixed-use, elementary school and warehouses.[51] A key finding of the study specific to Portland's efforts at climate reduction suggests that, "if the city of Portland were to retrofit and reuse the single-family homes and commercial office buildings that it is otherwise likely to demolish over the next 10 years, the potential impact reduction would total approximately 231,000 metric tons of CO2 – approximately 15% of their county's total CO2 reduction targets over the next decade."[52] One of the main findings was that "building reuse almost always yields fewer environmental impacts than new construction when comparing buildings of similar size and functionality."[53] The foundation of this finding was the avoided impacts framework – that is how much energy savings and other related environmental impacts occurred when new construction has been avoided.[54]

The *Greenest Building* report exemplifies the avoided impact approach by including the, "differences in impacts between reuse and new construction in the current day." This approach is what makes the report ground breaking and moves historic preservation forward in alignment with building and construction industry. Whereas previous generations of preservationists looked at the embodied energy of existing buildings this study breaks out of that mold:

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[50] Preservation Green Lab, National Trust for Historic Preservation, *The Greenest Building: Quantifying the Environmental Value of Building* (2011), 26.
[51] Ibid., 39.
[52] Ibid., VIII.
[53] Ibid., 61.
[54] Ibid., 20.

"The impacts associated with in situ materials occurred in the past and are not of interest in this study. Only the materials and activities related to the reuse and renovation of an existing building and those related to demolition and new construction are considered here."[55]

The report found that single family residential savings in the impact category of climate change was between 12 – 17%.[56] This immediate savings of carbon emissions indicates that reuse matters.

In *The Greenest Building* single family homes were identified as the, "most frequently torn down and replaced with new construction and in the context of Portland's current situation this rings true."[57] Consideration of *scale of impact* is integral to the relevance of this project. According to the report, while one building may not seem to be of "substantial" impact, "the absolute carbon-related impact reductions can be substantial when these results are scaled across the building stock of a city."[58] For example, if the city of Portland were to retrofit and reuse the single-family homes and commercial office buildings that it is otherwise likely to demolish over the next ten years, the potential impact reduction would total approximately 231,000 metric tons of CO2 – approximately 15% of their county's total CO2 reduction targets over the next decade."[59] An important project goal of this study is to build upon this analysis – to offer LCA as an innovate tool for the field of historic preservation.

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[55]Preservation Green Lab, National Trust for Historic Preservation, *The Greenest Building: Quantifying the Environmental Value of Building* (2011), 29.
[56]Ibid.
[57]Ibid.,39.
[58]Ibid., VIII.
[59]Ibid., VIII.

Case Study 2: Parks Canada

In 2009 Canadian Park Services and Athena Sustainable Materials Institute in association with Morrison Hershfield Consulting Engineers, completed *A Life Cycle Assessment Study of Embodied Effects for Existing Historic Buildings*. The objective of the case study was to create a template and methodology that could be replicated to determine environmental impacts of building new versus renovation.[60] Life Cycle Assessment was used to determine primary energy use and global warming potential measured in CO2 equivalence.[61] Avoided impacts were also calculated using Athena EcoCalculator to determine the impacts of similar new construction. The case study buildings received funding through a Government of Canada program, *Historic Places Initiative*. Funding was secured through the funding tool of the initiative, Commercial Heritage Properties Incentive Fund (CHPIF).[62] Three historic buildings were analyzed, including Parkdale Fire Station in Ottawa; Birks Building in Winnipeg and Lougheed Building in Calgary.

The avoided impacts approach of the Parks Canada case study included life cycle assessment of similarly sized new construction that would replace the historic buildings. The Athena Impact Estimator LCA modeling software was used to measure the embodied energy and global warming potential of the new construction. For example, the Parkdale Fire Station, 424 Parkdale Avenue, Ottawa, a fire station that had been rehabilitated for different use was measured. These measurements were then used to input "Proposed

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[60] Athena Sustainable Materials Institute, Prepared for Parks Canada, *A Life Cycle Assessment Study of Embodied Energy Effects for Existing Historic Buildings*, (Canada: Athena Materials Institute, 2009), 1.
[61] Ibid., 2.
[62] Ibid., 1.

Typical Replacement Building" assemblies including height, massing, window to wall ratio and "similar interior configuration."[63] The results of the Parkdale Fire Station Total Avoided Impacts showed that 184.76 tons of carbon energy use of 85.2 homes per year.[64] Translating this information into relatable terms; the project team utilized the EPA's Greenhouse Gas Equivalencies Calculator to convert the LCA impact assessment into terms that are easily understood. For example, carbon emissions are equivalent passenger vehicles driven for one year or gallons of gasoline consumed. At a policy level, collaboration between the Canadian government and Athena is important because it demonstrates the integration of LCA modeling with historic preservation.

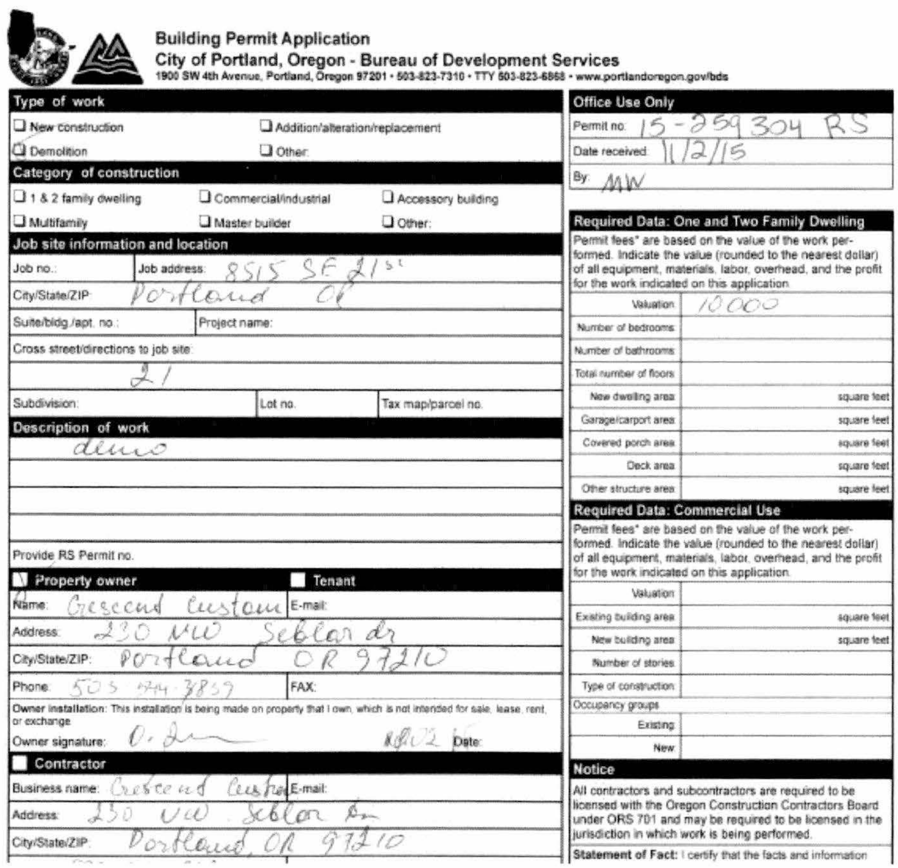
[63] Ibid., 7.

[64] Athena Sustainable Materials Institute, Prepared for Parks Canada, *A Life Cycle Assessment Study of Embodied Energy Effects for Existing Historic Buildings*, (Canada: Athena Materials Institute, 2009), 8.

Chapter V: Sellwood: A Case Study Using LCA

Single Family Demolition and Replacement at 8515 SE 21st

In Portland, when a property owner decides to demolish an existing building, the individual is required to follow a process that begins with a demolition application issued through the Bureau of Development Services. As a primary source of information, permits are rich in information and give clues about management of existing buildings at the city government level.



Building Permit Application
City of Portland, Oregon - Bureau of Development Services
1900 SW 4th Avenue, Portland, Oregon 97201 • 503-823-7310 • TTY 503-823-6868 • www.portlandoregon.gov/bds

Type of work
☐ New construction ☐ Addition/alteration/replacement
☐ Demolition ☐ Other:

Category of construction
☐ 1 & 2 family dwelling ☐ Commercial/industrial ☐ Accessory building
☐ Multifamily ☐ Master builder ☐ Other:

Job site information and location
Job no.: Job address: 8515 SE 21st
City/State/ZIP: Portland OR
Suite/bldg./apt. no.: Project name:
Cross street/directions to job site:
21
Subdivision: Lot no. Tax map/parcel no.

Description of work
demo

Provide RS Permit no.

Property owner **Tenant**
Name: Crescent Custom E-mail:
Address: 230 NW Seblar dr
City/State/ZIP: Portland OR 97210
Phone: 503 [illegible]-3859 FAX:
Owner installation: This installation is being made on property that I own, which is not intended for sale, lease, rent, or exchange
Owner signature: Date:

Contractor
Business name: Crescent Custom E-mail:
Address: 230 NW Seblar Dr
City/State/ZIP: Portland, OR 97210

Office Use Only
Permit no: 15-259304 RS
Date received: 11/2/15
By: MW

Required Data: One and Two Family Dwelling
Permit fees* are based on the value of the work performed. Indicate the value (rounded to the nearest dollar) of all equipment, materials, labor, overhead, and the profit for the work indicated on this application.

Valuation	10000
Number of bedrooms	
Number of bathrooms	
Total number of floors	
New dwelling area	square feet
Garage/carport area	square feet
Covered porch area	square feet
Deck area	square feet
Other structure area	square feet

Required Data: Commercial Use
Permit fees* are based on the value of the work performed. Indicate the value (rounded to the nearest dollar) of all equipment, materials, labor, overhead, and the profit for the work indicated on this application.

Valuation	
Existing building area	square feet
New building area	square feet
Number of stories	
Type of construction	
Occupancy groups	
Existing	
New	

Notice
All contractors and subcontractors are required to be licensed with the Oregon Construction Contractors Board under ORS 701 and may be required to be licensed in the jurisdiction in which work is being performed.
Statement of Fact: I certify that the facts and information

Figure 3. Demolition Permit issued by the City of Portland Bureau of Development Services. Each permit and proposed new development is issued a number with an RS (Residential Single).

A typical demolition permit includes a variety of information including the names of previous and current owner, new construction plans (often including architectural drawings), required environmental-related documentation including sewer systems, soil sampling, asbestos and lead paint abatement information and sometimes a footprint of the house slated for demolition (Figure 4). Documentation of existing buildings such as floor plans and photographs of the existing building are often not included in the permit documents. Information about the existing building is specifically in the context of demolition and as a result the level of documentation varies.

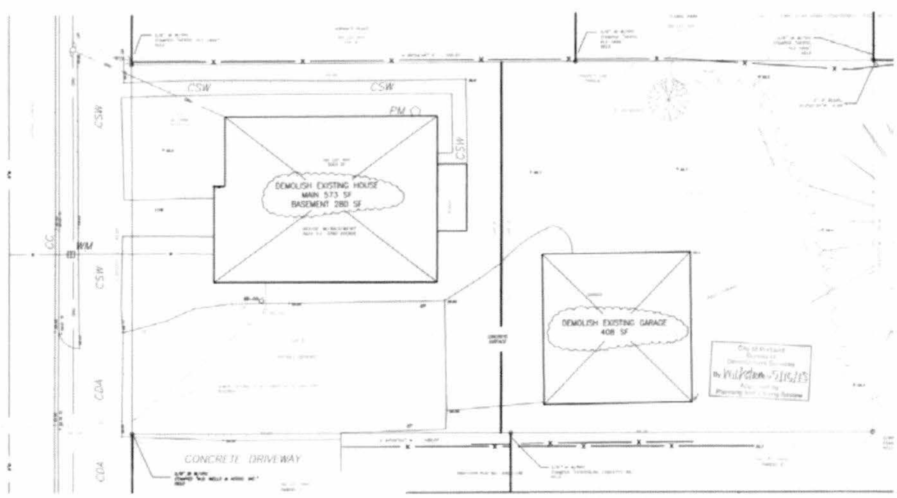


Figure 4. Site plan of address 5624 SE 22nd existing buildings to be removed.

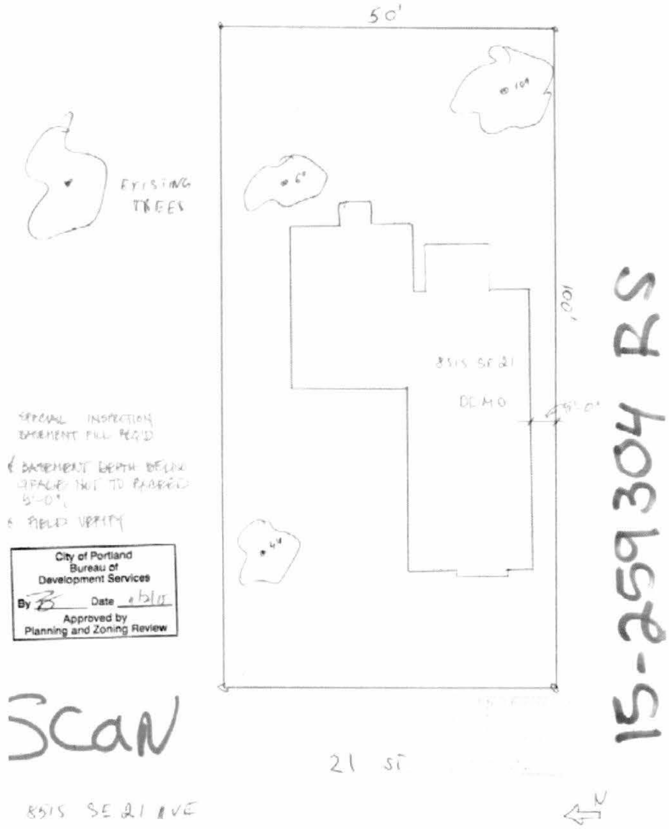


Figure 5. Address 8515 SE 21st Ave. hand sketched site plan including footprint of existing building to be demolished.

Without consistent documentation of existing buildings, proper analysis of specific building construction assemblies is a challenge. This is important in terms of capturing a more accurate estimate of the embodied energy in the existing building. Missing information about the building's details including floor plans, types of building materials, fixtures, HVAC systems etc. suggest a fast-paced process that does not consider impacts of what is being lost. Furthermore, without an environmental assessment of either the existing or new replacement construction it is impossible to determine the environmental value of reuse in comparison to the impact of new construction.

In the context of this project, methodology of permit research is an integral part of the investigation into the intersection of land use planning, management of historic resources and ultimately demolition-driven redevelopment. As a written record permits offer an impartial offering of pertinent information regarding building typology, construction material, applicable land use (zoning) and specific neighborhood location. Determination of the case study property was based on analysis of demolition permits issued in 2015. Permits were reviewed for location, housing type and date of construction. Each permit and corresponding physical address were accessed using the City of Portland, Bureau of Development Services (BDS) "Metro Reports" which is a listing of a variety of permits including commercial and residential. The weekly "Issued Residential Reports" from January 1 – December 30, 2015 served as primary source material from which a list of demolition permits was established. A top-down approach was taken, beginning with the total demolition permits issued city-wide, next permits were sorted by zip code and then by neighborhood (see appendix for complete table). This methodology was utilized to maintain a level of objectivity with no preference given to a particular neighborhood based on the author's personal preference. Analysis concluded the zip code of 97202 had the largest number of permits issued - 51 in total (figure 6). Within the 97202 zip code, the neighborhood of Sellwood-Moreland neighborhood had a total of 21 demolition permits issued.

Neighborhood	Total Demolition Permits Issued in 2015 within zip code 97202
Sellwood-Moreland	21
Richmond	5
Woodstock	3
East Moreland	8
Creston-Kenilworth	7
Hosford-Abernethy	5
Brooklyn	2
Total Permits	**51**

Figure 6. Table represents the total of demolition permits issued in the 97202 zip code.

The process of case study property selection was based on the availability of complete architectural drawings for new construction. In the initial process of narrowing down the case study property, two types of new construction were selected to represent common redevelopment scenarios: demolition of existing single family homes with replacement of new single residential home and demolition of existing single family homes with replacement of multi-family housing (apartments). However, based on the limited time and the complexity of calculating the Life Cycle Impacts with recognition of potential energy savings per unit of new multi-family construction, the latter option was eliminated. The table below illustrates the four properties remaining from the 21 that had the most complete documentation including architectural drawings.

Address	Development type	Level of Architectural Information	Date of Construction
1650 SE Harold St.	Single to apt	Very complete	1904
5624 SE 22nd Ave. (northern)	Single to apt	Very complete	1910-1920
8515 SE 21st Ave (southern)	Single to single	Very complete	1909
1416 SE Clatsop St. (southern)	Single to single	Very complete	1908

Figure 7. Table Shows the process of elimination used to determine the specific case study property.

Of the two properties remaining, both of which are existing single family homes replaced with new single-family homes, 8515 SE 21st Ave. was selected with a basic toss of the coin.

Athena Impact Estimator

In order to meet the stated Project Goal 1 which was focused on gaining an understanding of LCA through practical application, it was determined that the LCA modeling software Athena Impact Estimator (IE) was an appropriate choice given its use in architecture and construction practice. The free software is available through the Athena Sustainable Materials Institute, an environmental think tank that specializes in Life Cycle Assessment for products, including buildings. Athena Impact Estimator is a whole building analysis; its stated purpose is to "understand how to reduce embodied impacts of the construction sector."[65] This tool is used most often in the design stages of new constructions and renovations. While there are a few case studies of historic buildings that utilize Athena Impact Estimator, the software is not traditionally used by the Historic Preservation field. The fact that the building assemblies are not reflective of old materials makes the process of estimation a bit more complicated and may be one reason that it hasn't been widely utilized by the preservation community. The software uses its own Life Cycle Inventory (LCI) database, which has specific metrics associated with different types of materials used predominantly for new construction. This software utilizes building assemblies, which includes walls, windows, beams/columns, floor systems along with other items not included and appear under "extra construction" category. While this project focuses on the carbon emissions associated with demolitions, the software has seven different impact areas, which include fossil fuel use, global warming potential, acidification, human health particulates, eutrophication, ozone depletion and smog. For the purposes of this project, the focus will be carbon emissions – global warming potential (GWP).

ISO 14044

The LCA modeling for this case study is very loosely based on the standards established by the International Organization for Standardization or ISO. ISO defines itself as an,

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[65] Athena Sustainable Materials Institute, *User Manual and Transparent Document: Impact Estimator for Buildings v. 5*, (September, 2014), 5.

"... independent, non-governmental international organization with a membership of 163 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges."[66]

ISO Standards ISO 14044:2006, "Environmental management -- Life cycle assessment – Principles" offers a framework of guidelines for life cycle assessment (LCA) including,

"definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements."[67]

This project utilizes four stages of the ISO including, 1) Definition of the goal and scope of the LCA, 2) Life cycle inventory analysis 3) Life cycle impact assessment and 4) Interpretation of Results.

Determination of the goal and scope

The goal of this Life Cycle Assessment (LCA) is to identify the global warming potential (GWP) impact of a new single-family house construction in Portland, Oregon. It is important to note the scope serves the purpose of meeting the stated Goals outlined in the beginning of the study. This LCA is not expansive by design - a "streamlined LCA,"[68] limited in scope for the purpose of preliminary data creation. The table below summarizes the scope.

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[66] International Organization for Standardization (ISO), *About ISO,* Accessed November 2016 http://www.iso.org/iso/home/about.htm.
[67] Ibid.
[68] Robert H. Crawford. *Life Cycle Assessment in the Built Environment*, (New York: Spoon Press, 2011), 42.

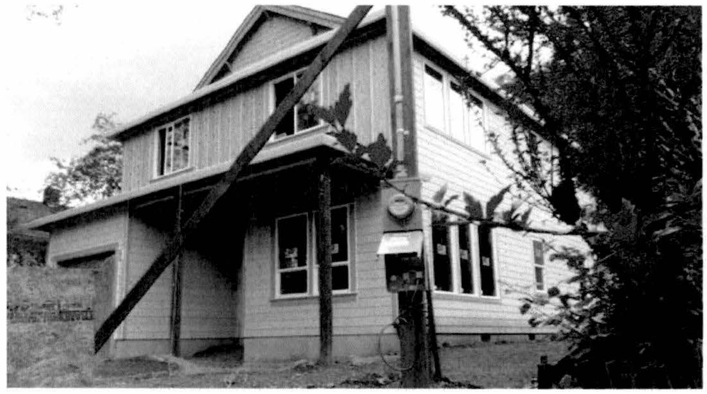

Figure 8. A new single-family home construction located at 8515 SE 21st Ave., Portland Oregon. photo taken by author, April 2016.

Year Built	2016
Location	8515 SE 21st Ave
Building Height	2-story
Square Footage	2,911
Structure Type	Prefab Truss System
Envelope	2x6 wood framing, R-21 batt insulation, OSB Sheathing
Layout	4 bedroom, 3 bath
Cladding	Wood

Figure 9. New single family home property information.

System Boundary Diagram

The goal and scope of this LCA is illustrated through a System Boundary Diagram, a graphic which defines the relevant, "inputs, outputs and processes that are to be included in an LCA study."[69] The system boundary illustrates which processes of the product (single family home) system are included in the study. This LCA includes analysis of inputs and outputs of energy and resources used to build the assemblies of which the new single family is constructed. These processes are correlated in the Life Cycle Inventory, each with an attached environmental impact. This system boundary does not include the inputs and outputs of operating a building over its life time or demolition phase.

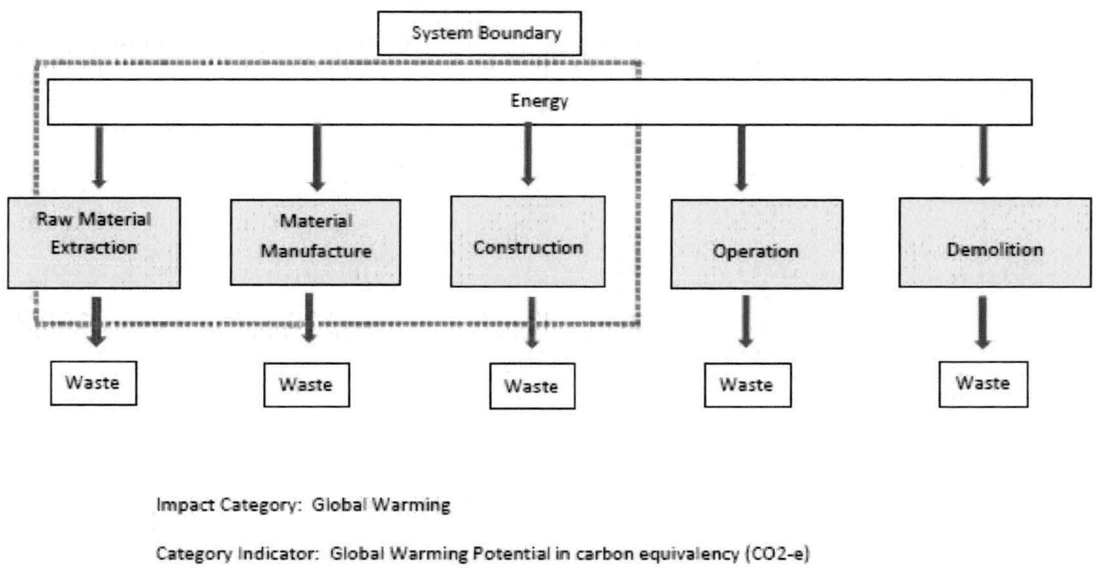

Figure 10. System boundary diagram illustrates the streamlined LCA. Inputs include energy used during the process of raw material extraction, material manufacture, construction. Outputs include waste which for the purpose of this study is measured in carbon equivalency.

Functional Unit

The purpose of the functional unit is to provide a description of the product that will be assessed using a "common unit of measurement"[70] that can be used as a comparison against other products. The functional unit in this study is a newly constructed 2,900

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[69]Robert H. Crawford, *Life Cycle Assessment in the Built Environment*, (New York: Spoon Press, 2011), 25.
[70]Ibid., 44.

square foot home. The single-family home includes the major building assemblies, including the foundation, exterior & interior walls, windows, doors, garage door, roof and 1st and second floors.

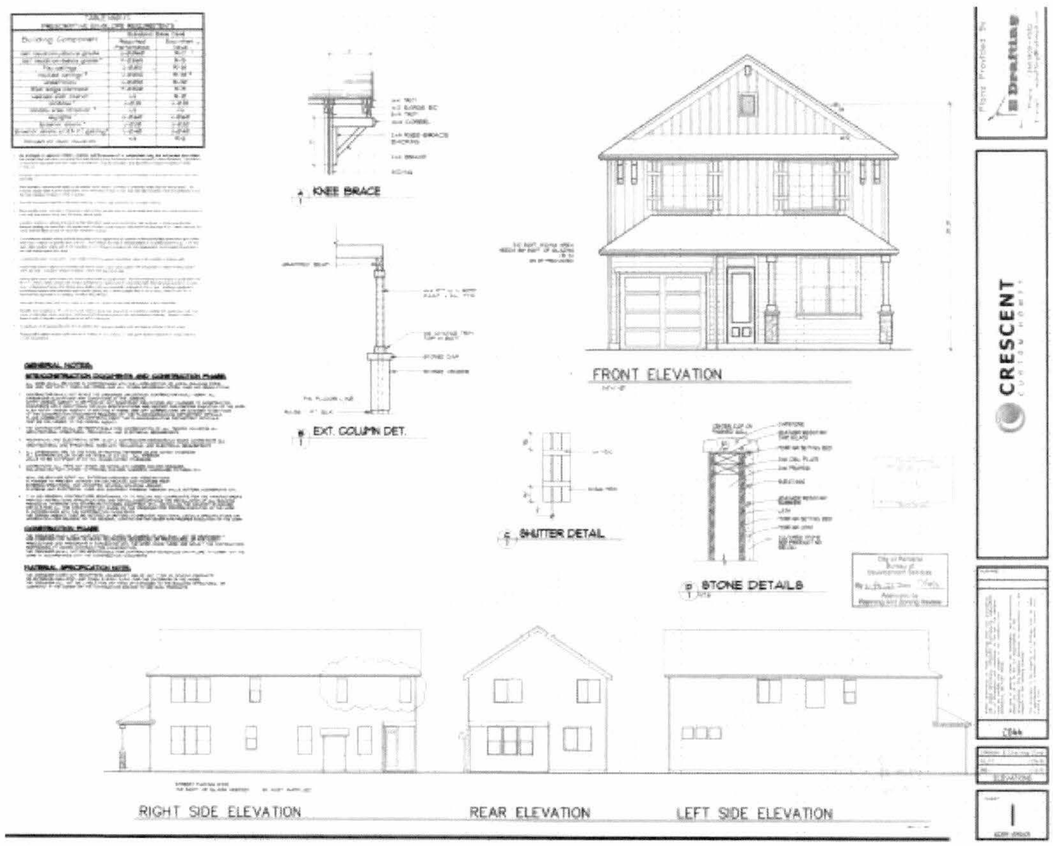

Figure 11. Functional unit for this LCA includes the building envelope, interior floors, foundation, windows, and roof of a 2,900 square foot, two-story single-family house. Architectural drawings by Crescent Custom Homes.

Life Cycle Inventory Analysis

The Life Cycle Inventory step is an integral part of the LCA because it includes the mechanism by which materials – in this case the building assemblies – are assessed and assigned specific values.[71] Specifications from the architectural drawings of the new single-family house were entered in Athena Impact Estimator. The Athena LCI Database including the information found in the Impact Estimator has its own "ISO 14040/14044 - compliant unit process LCA data"[72] of products, materials as well as the energy use, transportation, construction and demolition processes of construction assemblies. Most applicable to this study are the raw material extraction, material manufacture, and construction of the assemblies of a 2,900-square foot single family home. The list of building materials below which included in each assembly are part of Athena's Life Cycle Inventory. Each unit of material has an associated impact. For example, for the total 1139 square feet of 1/2 Gypsum Fibre Board there are impacts associated with the extraction, production and manufacture of the material.

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[71] American Institute of Architects (AIA), *Guide to Building Life Cycle Assessment in Practice,* (Washington, DC: The American Institute of Architects, 2010), 16.
[72]Athena Sustainable Materials Institute, *User Manual and Transparent Document: Impact Estimator for Buildings v. 5*, (September, 2014), 15.

BILL OF MATERIALS

Bill of Materials Report

Project: New Single Family Home 8515 SE 21st Ave

Material	Unit	Total Quantity	Columns & Beams	Floors	Foundations	Roofs	Walls	Extra Basic Materials	Mass Value	Mass Unit
#15 Organic Felt	100sf	226.7458	0	0	0	94.0873	132.6585	0	1.6946	Tons (short)
1/2" Regular Gypsum Board	sf	6130.1164	0	0	0	0	6130.1164	0	5.0599	Tons (short)
5/8" Regular Gypsum Board	sf	4040.5748	0	1770.9999	0	2269.5749	0	0	4.2579	Tons (short)
6 mil Polyethylene	sf	344.7600	0	0	344.7600	0	0	0	0.0053	Tons (short)
Aluminum Extrusion	Tons (short)	0.0763	0	0	0	0	0.0763	0	0.0763	Tons (short)
Concrete Benchmark 3000 psi	yd3	18.8371	0	0	18.8371	0	0	0	36.4122	Tons (short)
Expanded Polystyrene	sf (1")	46.7154	0	0	0	0	46.7154	0	0.0034	Tons (short)
FG Batt R20	sf (1")	23538.7996	0	0	0	0	23538.7996	0	0.6493	Tons (short)
FG Batt R40	sf (1")	35182.0850	0	35182.0850	0	0	0	0	0.8086	Tons (short)
FG LF Open Blow R31-40	sf (1")	25541.6738	0	0	0	25541.6738	0	0	0.5439	Tons (short)
Fiber Cement	sf	1380.1333	0	0	0	0	1380.1333	0	1.9777	Tons (short)
Fine Aggregate Natural	Tons (short)	9.0000	0	0	0	0	0	9.0000	9.0000	Tons (short)
Galvanized Sheet	Tons (short)	0.3801	0	0.0544	0	0.2347	0.0910	0	0.3801	Tons (short)
Glass Based shingles 30yr	100sf	34.6637	0	0	0	34.6637	0	0	4.5581	Tons (short)
Glazing Panel	Tons (short)	0.1490	0	0	0	0	0.1490	0	0.1490	Tons (short)
Joint Compound	Tons (short)	1.0395	0	0.1810	0	0.2320	0.6265	0	1.0395	Tons (short)
Large Dimension Softwood Lumber, kiln-dried	Mbfm large dimension	5.2560	0	5.2560	0	0	0	0	4.1046	Tons (short)
Nails	Tons (short)	0.3125	0	0.0882	0	0.0516	0.1728	0	0.3125	Tons (short)
Oriented Strand Board	msf (3/8")	4.4887	0	0	0	2.7365	1.7522	0	2.7757	Tons (short)
Paper Tape	Tons (short)	0.0119	0	0.0021	0	0.0027	0.0072	0	0.0119	Tons (short)

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Bill of Materials Report

Project: New Single Family Home 8515 SE 21st Ave

PVC Window Frame	lbs	1282.5380	0	0	0	0	1282.5380	0	0.6413	Tons (short)
Rebar, Rod, Light Sections	Tons (short)	0.4687	0	0	0.4687	0	0	0	0.4687	Tons (short)
Screws Nuts & Bolts	Tons (short)	0.1792	0	0	0	0	0.1792	0	0.1792	Tons (short)
Small Dimension Softwood Lumber, kiln-dried	Mbfm small dimension	276.7720	0	0	0	2.6897	6.2423	267.8400	210.3227	Tons (short)
Softwood Plywood	msf (3/8")	10.5891	0	5.9682	0	0	4.6208	0	5.1227	Tons (short)
Solvent Based Alkyd Paint	Gallons (us)	0.1038	0	0	0	0	0.1038	0	0.0003	Tons (short)
Water Based Latex Paint	Gallons (us)	194.0609	0	37.4017	0	47.9310	108.7282	0	0.6073	Tons (short)
Welded Wire Mesh / Ladder Wire	Tons (short)	0.0301	0	0	0.0301	0	0	0	0.0301	Tons (short)

Figure 12. The 'bill of materials report' is calculated by the Athena Impact Estimator life cycle inventory of building materials.

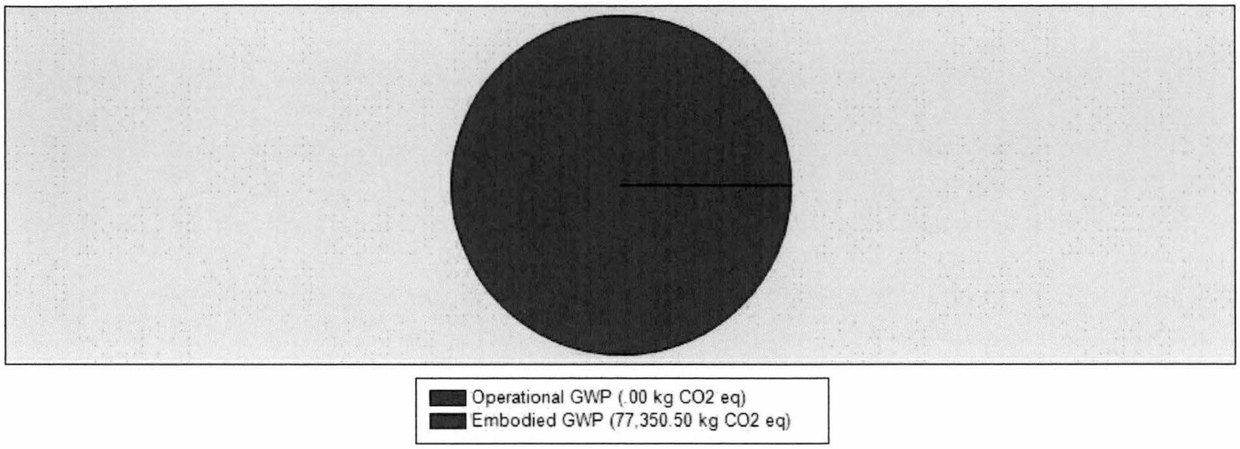
Life Cycle Impact Assessment

This study examines global warming potential (GWP) associated with new construction. GWP is based on the analysis of energy flows and the process by which materials consume resources and energy while outputting waste in the form of greenhouse gases (GHG). This impact category is measured in 'carbon equivalency' expressed as CO2E – in kg or tonnes CO2 equivalent.[73] Carbon dioxide is the most prevalent of the GHGs, the other three being methane and nitrous oxide. The Intergovernmental Panel on Climate Change (IPCC) first defined GWP in the 1990s as a system of measuring multiple gases, which were identified in the Kyoto Treaty and were specifically used to, "help assess the climate impacts of switching from chlorofluorocarbons to hydrofluorocarbons."[74] A wider application of the GWP soon became popular and was used to, "compare the climate impact of emissions of CO2 with non-CO2 greenhouse gases".[75] Life Cycle Inventories are a database of items that have an associated GHG footprint which result from processing of materials. Each item has an associated estimated impact that is expressed in carbon equivalency.[76] The report below from the Impact Estimator is generated from the materials that comprise different assemblies of the new single-family house construction.

[73] Athena Sustainable Materials Institute, *User Manual and Transparent Document: Impact Estimator for Buildings v. 5*, (September, 2014), 46.
[74] Keith Shine, "The global warming potential—the need for an interdisciplinary retrial. An editorial comment," *Climatic Change*, no. 96 (2009), 467.
[75] Keith Shine, "The global warming potential—the need for an interdisciplinary retrial. An editorial comment," Climatic Change, no. 96 (2009): 476.
[76] Athena Sustainable Materials Institute, *User Manual and Transparent Document: Impact Estimator for Buildings v. 5*, (September, 2014), 46.

Operational vs Embodied Global Warming Potential (A to C)

Project New Single Family Home 8515 SE 21st Ave



Operational GWP	Embodied GWP	Unit	Total
0.0	77,350.5	kg CO2 eq	77,350.5

Figure 13. A report generated from Athena Impact estimator representing the embodied energy global warming potential of building assemblies in carbon equivalency (co2 eq).

Interpretation

Results of the Impact Estimator indicate that the Embodied Energy Global Warming Potential (GWP) is 73,350.5 kg or tonnes CO2 eq. (carbon equivalency). It is worth noting that carbon equivalency is represented by the metric measurement, "tonne." In order to maintain a level of accuracy, the tonne is used for initial calculations and then later translated into imperial system measurements for easy comprehension. To put this into context, the Department of Environmental Quality (DEQ) Life Cycle Assessment conducted in 2010 as part of waste prevention strategy the impacts of a standard single family home. The report used a standard home size of 2,262 sq. ft. built with modern construction materials and used "as a baseline to which all waste prevention practices can be evaluated against."[77] As illustrated in the graph below the majority of the climate change impacts were from the operational energy which occurred during the life cycle of the house. The DEQ study looked at the impacts associated with Pre-Occupancy, Occupancy and Post-Occupancy. This study of the 8515 SE 21st Ave single family home is the Pre-Occupancy phase which includes original materials production, construction and materials transportation. Based on those phases it appears that the total of 73,000 kg CO2E is within the range of these categories (Figure 14).

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[77]Oregon-Department of Environmental Quality (DEQ), Prepared for DEQ by Quantis, Earth Advantage, and Oregon Home Builders Association, *A Life Cycle Assessment Based Approach to Prioritizing Methods of Preventing Waste from Residential Building Construction, Remodeling, and Demolition in the State of Oregon Phase 1 Report Version 1.2*, (Salem: Quantis, 2009), 10.

IV. Phase 1 Results

Overview of results for the standard home

The total climate change impact over the life cycle of the standard home are shown in Figure 5.

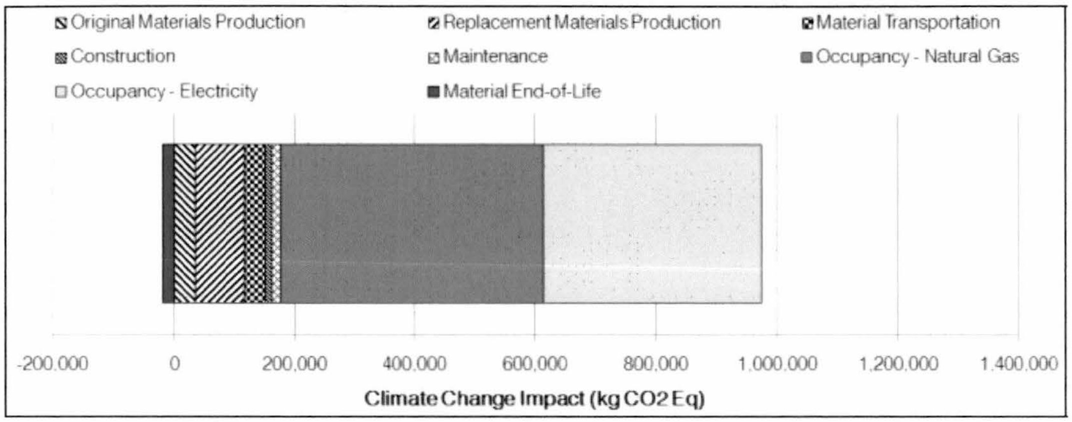

Figure 5: Climate change impact for the standard home by stage of the home life cycle

Figure 14. Oregon Department of Environmental Quality (DEQ), A Life Cycle Assessment Phase I Report, indicates Impacts of Climate Change in kg Carbon Equivalencies.

Application of Results

The LCA results is most relevant when applied to the accumulated demolitions of existing single-family homes that were replaced with new single-family homes. This is in alignment with a finding from the Preservation Green Lab Report, *The Greenest Building*, "reuse-based impact reductions may seem small when considering a single building. However, the absolute carbon-related impact reductions can be substantial when these results are scaled across the building stock of a city."[78] Applying this recommendation to Portland, analysis of the 118 existing single-family homes replaced

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[78] Preservation Green Lab, National Trust for Historic Preservation, *The Greenest Building: Quantifying the Environmental Value of Building Reuse*, (2011), VIII.

with new single-family homes in 2015 reveals the average home size of 2,500 square feet.[79]

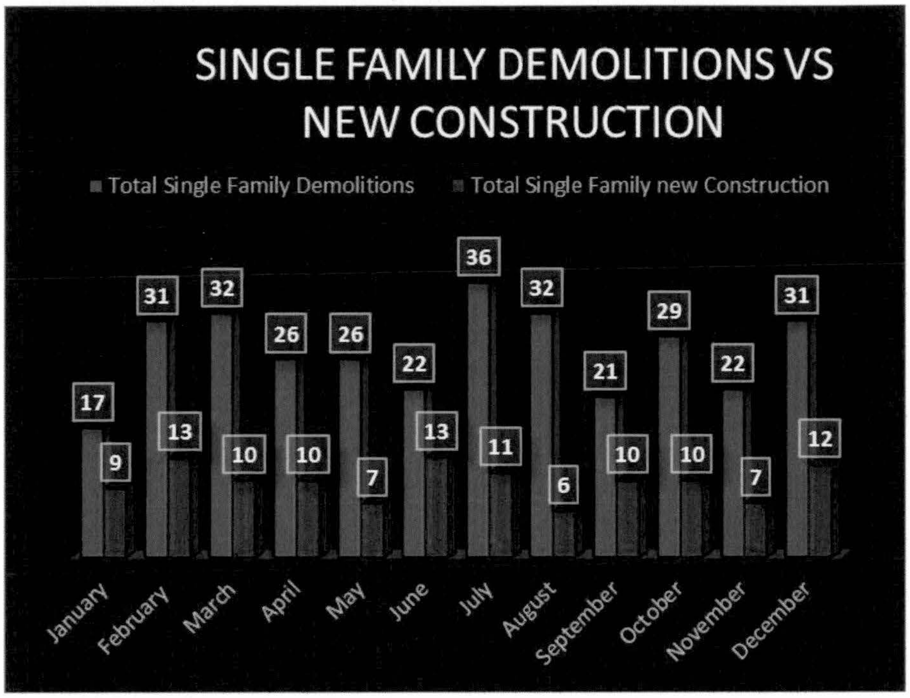

Figure 15. This graph shows a total of 118 new single family homes Built that replaced demolitions of existing single family homes.

In context of the average size of new construction, this number is within the range used in the Oregon Department of Environmental Quality, which utilized a slightly smaller standard size of 2,262 square feet.[80] The case study property of 2,900 square feet with an estimated impact of 73,000 kg of CO2 Equivalency, equates to 25 kg/ sq. ft. The total square footage of the 118 existing single-family houses demolished and

[79] This number is derived from original research by author.
[80] Oregon-Department of Environmental Quality (DEQ), Prepared for DEQ by Quantis, Earth Advantage, and Oregon Home Builders Association, *A Life Cycle Assessment Based Approach to Prioritizing Methods of Preventing Waste from Residential Building Construction, Remodeling, and Demolition in the State of Oregon Phase 1 Report Version 1.2*, (Salem: Quantis, 2009), 11.

replaced with new single-family houses is approximately 295,000 sq. ft. Multiplying the 25 kg/sq. ft. by the 295,000 sq. ft. is a total of 7,399,050 kg of CO2e.

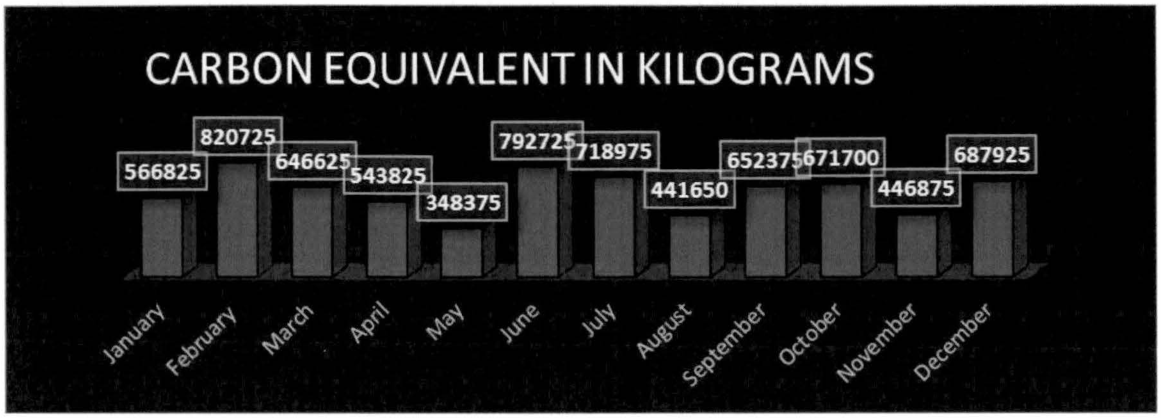

Figure 16. Total carbon for new single family construction that replaced existing buildings in 2015 broken down by month.

Converting the kilograms to tons, the total estimated impacts in tons of carbon equivalents is approximately 8,000 tons. To put this number into perspective, according to the EPA Greenhouse Gas Equivalencies Calculator 8,000 tons is equivalent to CO2 emissions from 816,000 gallons of gasoline and 1,072 homes' electricity use for one year.[81]

The total 8,000 tons of CO2e is an estimate of impacts and should consider a margin of error which assumes that construction materials of the case study property differ from that of the materials used in the construction of the 118 new single-family homes. This variation of construction materials means that the kg/sf calculation utilized for the 7 million kg of CO2 is an estimate. For example, roofing and siding material likely vary with new single family house construction and as a result estimated impacts would affect the total embodied energy.

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[81] Environmental Protection Agency (EPA), *Greenhouse Gas Equivalencies Calculator*, Accessed November 2016, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

CONCLUSION & RECOMMENDATIONS

While this research effort stands somewhat outside the paradigm of conventional historic preservation, there is value in taking on issues that directly affect the field using a diverse set of tools such as Life Cycle Assessment. I view the results as standing on the precipice of possibility. By looking at the destruction of existing buildings from a macro level within Portland's efforts to minimize carbon impacts there is opportunity to broaden historic preservation. This new perspective could assist Portland with the challenges of balancing protection of historic resources with development pressures, shifting demographics and population growth. Fostering a better understanding of how reuse compliments and builds the foundation of a sustainable city is one way we as preservation professionals can continue to make the field relevant. And while there is no expectation that cities must be frozen in time, there is opportunity to think about management of existing buildings from a perspective of added environmental value.

Connecting demolition of single family homes with replacement new single family homes is the first step towards an integrated policy approach that is in alignment with objectives of progressive Oregon environmental policy, historic preservation efforts and local Portland efforts to minimize carbon emissions. Suggestions for policy adjustments that encourage reuse and consider impacts of new construction are targeted at specific regulations that will yield the most impact. These suggestions are in part based on suggested further research that could guide these changes. An integrated policy model will allow a progressive approach to historic preservation and mitigation of carbon impacts. Collaboration between seemingly disparate areas within the city is integral to begin asking the questions posed throughout my research. A pilot program such as the Historic Initiative that funded the Parks Canada LCA case study would provide a good first step to determine the initial first steps to clearly connect management of historic resources and carbon emission goals. Amending the Carbon Action Plan to more strongly build the case for retention of existing buildings (both those identified as significant and vernacular) would be a good first start. In addition, adding incentives for reuse that are coached in terms of carbon emissions would be helpful, perhaps through a carbon tax that makes it more costly tearing down a single-family home and replace with a new single family home. A carbon tax is discussed in the Climate Action Plan as a potential future course of action. In this case, the preservation community could rally to include demolitions of buildings in new proposed policy. Creating a dialogue and partnering with organizations such as Earth Advantage and Oregon Trust would be a good first step to building bridges between traditional preservation groups and those focused on energy efficiency through technology.

FUTURE RESEARCH

In order to fully understand the overall implications of carbon impacts of new construction and demolitions it is important to consider the triple bottom line of sustainability. The economic and socio-cultural elements are as important as the carbon impacts of climate change that occur as a result of demolitions. Gentrification is clearly evident in the current redevelopment of properties, when single family homes are purchased, demolished and then sold for (approximately) double the amount of the original home's selling price. Implications of demographic shifting as a result of increased property value and the perceived loss of historic resources are all worthy of further research. Recent demolitions are part of a historical pattern of displacement in Portland, most recently which occurred on a large scale to the African American community which experienced significant displacement during urban renewal and in the 1990s and 2000s in North and NE Portland. The larger forces that have affected urban redevelopment in this area are similar to currently at the root of recent demolitions. These underlying power dynamics include lack of representational leadership and weak process democracy.

Identification of specific policy effectiveness would be helpful to determine where specific adjustments should be made. For example, policies outlined in the 2035 Portland Comprehensive Plan are not easily revised once the public comment period is closed and the policy is voted into action by the City Council. However, an ordinance like the Demolition Ordinance which went into effect in February 2015 and outlines specific procedures for delaying destruction of historic resources has more flexibility and could be more easily implemented. In addition, a policy like the Climate Action Plan which plans in five year increments would also be a good place to include more provisions for protection of historic resources. Further research that includes a historical perspective on the effectiveness of specific properties would be a good starting point. However, before undertaking any specific research it is essential to consult with public agencies as well as community leaders to ensure that the right questions are asked.

APPENDIX

A. Demolition permits requested and issued in 2015 by month. Note that permits issued in 2016 were considered in overall total of 2015 demolitions. Pages 57-69.

	Permit #	Date Requested	Date of Issue	Address	Zip Code	Type	Commercial	Residential
				January				
1		1/27/15	1/27/16	50 SE 13th Ave		single story restaurant	x	
2		1/7/15	1/7/15	5000 SE LINCOLN ST		2 story building	x	
3		1/16/15	1/16/16	8157 N LOMBARD ST		900 SF office	x	
4		11/26/14	1/29/15	7705 SE DIVISION ST		office/medical	x	
5		1/9/15	1/9/16	1459 SE ANKENY ST		2 story apartment with commercial	x	
6		1/13/15	1/13/15	5625 E BURNSIDE ST		2 story comm	x	
7		12/5/14	1/12/15	3205 NE MULTNOMAH		Duplex apartment		x
8		11/20/14	1/30/15	2534 N ARGYLE ST	97217	single family		x
9		1/26/15	1/26/15	3327 SE 65TH AVE	97206	single family		x
10		1/26/15	1/26/15	9509 SW 46TH AVE	97219	single family		x
11		12/16/14	1/23/15	9024 SE YAMHILL ST	97216	single family		x
12		1/23/15	1/23/15	2403 SE ANKENY ST	97214	single family		x
13		12/12/14	1/21/15	1113 N TERRY ST	97217	single family		x
14		1/16/15	1/16/15	1507 SE MARION ST		single family		x
15		12/3/14	1/15/15	1706 SE 130TH AVE	97233	single family		x
16		1/15/15	1/15/15	31	97203	single family		x
17		1/13/15	1/13/15	2238 NE GLISAN ST	97232	single		x
18		8/13/14	8/13/15	11405 SE RAMONA CT	97266	single family		x
19		12/5/14	1/12/15	9635 SW 48TH AVE	97219	single family		x
20	15-103036-000-00-RS	1/9/15	1/9/15	5217 NE 28TH AVE	97211	single family		x
21	15-102336-000-00-RS	1/8/15	1/8/15	3225 NE 29TH AVE	97212	single family		x
22	14-251140-000-00-RS	1/5/15	1/5/15	1144 SE MILLER ST	97202	single family		x
23	14-252421-000-00-RS	12/24/14	1/30/15	1537 NE 72ND AVE	97213	single family		x
24	13-189259-000-00-RS	8/6/13	1/5/15	7127 SE 122ND DR	97236	single family		x

				February				
	Permit #	Date Requested	Date of Issue	Address	Zip Code	Type	Commercial	Residential
1	15-113331-000-00-CO	2/2/15	2/12/15	4041 NE M L KING BLVD	97212	office	x	
2	15-122518-000-00-CO	2/20/15	ınder reviev	7134 NE HALSEY ST	97213	gas station	x	
3	15-123405-000-00-CO	2/24/15	2/24/15	6300 N LOMBARD ST	97203	business	x	
4	15-123502-000-00-CO	2/24/15	2/24/15	6214 N LOMBARD ST	97203	business	x	
5	15-119101-000-00-CO	2/26/15	2/26/15	1241 NW JOHNSON ST	97209	business	x	
6	15-123230-000-00-RS	2/23/15	2/23/15	7308 N TYLER AVE	97203	single family		x
7	15-123785-000-00-RS	2/24/15	2/24/15	3215 SE BROOKLYN ST	97202	single family		x
8	15-123804-000-00-RS	2/24/15	2/24/15	021 SW IOWA ST	97201	single family		X
9	13-224396-000-00-RS	12/24/13	2/25/15	2152 SE 130TH AVE	97233	single family		X
10	15-107216-000-00-RS	1/20/15	2/25/15	5226 N HARVARD ST	97203	single family		X
11	15-107371-000-00-RS	1/20/15	2/25/15	3959 NE MALLORY AVE	97212	single family		x
12	14-192498-000-00-RS	8/12/14	2/26/15	3415 SE DIVISION ST	97214	single family		x
13	15-104139-000-00-RS	1/13/15	2/26/15	3936 SE REEDWAY ST	97202	single family		x
14	15-122559-000-00-RS	2/20/15	2/20/10	7215 N LANCASTER AVE	97217	single family		x
15	15-103810-000-00-RS	1/12/15	2/20/15	1525 SE 35TH PL	97214	single family		x
16	15-120188-000-00-RS	2/17/15	2/17/15	3609 SE 67TH AVE - Unit /	97206	single family		x
17	14-191442-000-00-RS	7/31/14	2/13/15	3418 N COMMERCIAL AVE	97227	single family		x
18	14-165087-000-00-RS	7/2/14	2/13/15	3435 NE 51ST AVE	97213	single family		x
19	14-211345-000-00-RS	9/11/14	2/13/15	5323 NE 12TH AVE	97211	single family		x
20	15-118822-000-00-RS	2/12/15	2/12/15	!27 N MASSACHUSETTS A\	97217	single family		x
21	15-118391-000-00-RS	2/11/15	2/11/15	3660 SE NEHALEM ST	97202	single family		x
22	14-255356-000-00-RS	12/31/14	2/11/15	7847 SE RAYMOND ST	97206	single family		x
23	15-117410-000-00-RS	2/10/15	2/10/15	10219 SE RAMONA ST	97266	single family		x
24	14-253609-000-00-RS	12/24/15	2/10/15	4241 NE AINSWORTH ST	97218	single family		x
25	14-222934-000-00-RS	10/8/14	2/9/15	100 N COOK ST	97227	single family		x
26	14-254082-000-00-RS	12/31/14	2/6/15	8236 SW 11TH AVE	97219	single family		x
27	15-115346-000-00-RS	2/6/15	2/6/15	6709 N MONTANA AVE	97217	single family		x
28	15-115849-000-00-RS	2/6/15	2/6/15	4210 SE 28TH AVE	97202	single family		x
29	15-114867-000-00-RS	2/4/15	2/4/15	3139 NE 48TH AVE	97213	single family		x
30	15-114247-000-00-RS	2/3/15	2/3/15	550 SW TAYLORS FERRY R	97219	single family		x
31	15-113992-000-00-RS	2/3/15	2/3/15	8226 SE 19TH AVE	97202	single family		x
32	15-112413-000-00-RS	2/3/15	2/3/15	9411 N TYLER AVE	97203	single family		x
33	15-113594-000-00-RS	2/2/15	2/2/15	7305 NE SISKIYOU ST	97213	single family		x
34	14-229552-000-00-RS	10/23/14	2/27/15	4025 N MISSISSIPPI AVE	97227	single family		x
35	14-212141-000-00-RS	9/12/14	2/2/15	5243 NE 15TH AVE	97211	single family		x
36	14-212140-000-00-RS	9/12/14	2/2/15	5245 NE 15TH AVE	97211	single family		x

March								
1	15-140823-000-00-CO	3/27/15	3/1/15	14400 N RIVERGATE BLVD	97203	commercial	x	
2	15-134872-000-00-CO	3/27/15	3/27/15	6931 NE M L KING BLVD	97211	commercial	x	
3	15-134864-000-00-CO	3/27/15	3/27/15	6931 NE M L KING BLVD	97211	commercial	x	
4	15-135402-000-00-CO	3/27/15	3/27/15	8045 NE AIRPORT WAY	97218	commercial	x	
5	15-135391-000-00-CO	3/27/15	3/27/15	8019 NE AIRPORT WAY	97218	commercial	x	
6	15-135400-000-00-CO	3/27/15	3/27/15	8035 NE AIRPORT WAY	97218	commercial	x	
7	15-135397-000-00-CO	3/27/15	3/27/15	8025 NE AIRPORT WAY	97218	commercial	x	
8	15-135379-000-00-CO	3/18/15	3/18/15	8007 NE AIRPORT WAY	97218	commercial	x	
9	15-130267-000-00-RS	3/9/15	3/9/15	6419 SE RAMONA ST	97206	5+ unit	x	
10	15-142791-000-00-RS	3/31/15	3/31/15	5406 SW WOODS CT	97211	single family	x	
11	15-117630-000-00-RS	3/2/15	3/2/15	1630 N HOLMAN ST	97217	single family		x
12	14-216481-000-00-RS	10/1/14	3/3/15	4407 N HAIGHT AVE	97217	single family		X
13	15-128655-000-00-RS	3/4/15	3/4/15	3122 NE 44TH AVE	97213	single family		X
14	15-128958-000-00-RS	3/5/15	3/3/15	5855 NE PRESCOTT ST	97218	single family		X
15	15-128994-000-00-RS	3/5/15	3/5/15	9144 N SMITH ST	97203	single family		X
16	14-197800-000-00-RS	8/13/14	3/6/15	6117 SE 65TH AVE	97206	single family		X
17	14-240434-000-00-RS	11/20/15	3/6/15	670 NW BEUHLA VISTA TE	97210	single family		X
18	15-129672-000-00-RS	3/6/15	3/6/15	4700 SE RURAL ST	97206	single family		x
19	15-129938-000-00-RS	3/6/15	3/6/15	006 NE EMERSON ST Unit	97211	single family		X
20	15-129127-000-00-RS	3/5/15	3/5/15	2605 SE 21ST AVE	97202	single family		X
21	15-108165-000-00-RS	1/29/14	3/9/15	6111 N CONCORD AVE	97217	single family		X
22	15-132063-000-00-RS	3/11/15	3/11/15	5405 N WILLAMETTE BLVD	97203	single family		X
23	15-132060-000-00-RS	3/11/15	3/11/15	3314 NE 75TH AVE	97213	single family		x
24	14-143041-000-00-RS	5/15/14	3/11/16	16 N MONTANA AVE, 972	97217	single family		x
25	15-132115-000-00-RS	3/11/15	3/11/15	11104 NE FARGO ST	97220	single family		x
26	15-114173-000-00-RS	2/3/15	3/12/15	1933 NW 23RD PL	97210	single family		x
27	14-222937-000-00-RS	10/18/14	3/12/15	32 N COOK ST	97227	single family		x
28	15-135059-000-00-RS	3/17/15	3/17/75	3558 NE 44TH AVE	97213	single family		x
29	15-134313-000-00-RS	3/17/17	3/17/15	5723 SE ASH ST	97215	single family		x
30	14-249048-000-00-RS	12/30/15	3/18/15	8311 SE BROOKLYN ST	97266	single family		x
31	15-137283-000-00-RS	3/20/15	3/20/15	2826 SE 49TH AVE	97206	single family		x
32	15-137571-000-00-RS	3/23/16	3/23/15	3722 SE TAYLOR ST	97214	single family		x
33	15-137568-000-00-RS	3/23/15	3/23/15	6011 N AMHERST ST	97203	single family		x
34	15-118382-000-00-RS	2/11/15	3/24/15	1333 SE 84TH AVE	97216	single family		x
35	15-139508-000-00-RS	3/25/15	3/25/15	2122 NE ALAMEDA ST	97212	single family		x
36	15-141044-000-00-RS	3/27/15	3/27/15	2318 NE RODNEY AVE	97212	single family		x
37	14-159551-000-00-RS	5/21/14	3/27/15	6205 N MINNESOTA AVE	97217	single family		x
38	15-140553-000-00-RS	3/30/15	3/30/15	2531 SE 18TH AVE	97202	single family		x
39	15-123030-000-00-RS	2/23/15	3/31/15	4934 NE 41ST AVE	97211	single family		x
40	15-123061-000-00-RS	2/23/15	3/31/15	2640 SE ANKENY ST	97214	single family		X
41	15-122641-000-00-RS	2/20/15	3/31/15	2740 SE 26TH AVE	97202	single family		X

				April				
1	15-142778-000-00-CO	3/31/15	4/9/15	801 NE FAILING ST	97212	commercial/ church	x	
2	15-146143-000-00-CO	4/8/15	4/8/15	5045 SE FOSTER RD	97206	commercial	x	
3	15-146475-000-00-CO	4/8/15	4/8/15	4937 SE DIVISION ST	97215	commercial	x	
4	14-253939-000-00-CO	1/20/15	4/27/15	2140 NW QUIMBY ST	97210	commercial	x	
5	15-122518-000-00-CO	2/20/15	4/1/15	7134 NE HALSEY ST	97213	commercial	x	
6	15-146484-000-00-CO	4/8/15	4/8/15	4851 SE DIVISION ST	97215	commercial	x	
7	15-150320-000-00-CO	4/16/15	4/16/15	7406 SE MILWAUKIE AVE	97202	commercial	x	
8	14-189228-000-00-CO	4/10/15	4/10/15	1481 NW 13TH AVE	97209	commercial	x	
9	15-156081-000-00-CO	4/24/15	4/24/15	2357 SE 50TH AVE	97215	commercial	x	
10	15-143127-000-00-CO	4/1/15	4/1/15	6437 SE DIVISION ST	97215	commercial	x	
11	15-150331-000-00-RS	4/16/15	4/16/15	0 SE MILWAUKIE AVE, 97	97202	single family		x
12	14-253383-000-00-RS	12/23/14	4/1/15	5350 SE 18TH AVE	97202	single family		x
13	15-155521-000-00-RS	4/23/15	4/23/15	7534 SW 31ST AVE	97219	single family		x
14	15-115860-000-00-RS	2/6/15	4/20/15	7558 SE DIVISION ST	97206	single family		x
15	15-124723-000-00-RS	2/25/15	4/15/15	3408 N HUNT ST	97217	single family		x
16	15-148495-000-00-RS	4/14/15	4/14/15	7211 N RICHARDS ST	97203	single family		x
17	15-151424-000-00-RS	4/17/15	4/17/15	6825 N GREENWICH AVE	97217	single family		x
18	14-234298-000-00-RS	11/5/14	4/14/15	1897 SW GREENWOOD RD		single family		x
19	15-132707-000-00-RS	3/18/14	4/24/15	8911 N HAVEN AVE	97203	single family		x
20	15-132371-000-00-RS	3/12/15	4/17/15	1650 SE HAROLD ST	97202	single family		X
21	15-147577-000-00-RS	4/10/15	4/10/15	3646 SE MARTINS ST	97202	single family		X
22	15-147691-000-00-RS	4/10/15	4/10/15	4816 NE CAMPAIGN ST	97218	single family		X
23	15-135239-000-00-RS	3/17/15	4/22/15	3405 NE 74TH AVE	97213	single family		X
24	15-127672-000-00-RS	3/3/15	4/9/15	015 SW IOWA ST	97201	single family		X
25	15-129919-000-00-RS	3/9/15	4/28/15	6606 SE TOLMAN ST	97206	single family		X
26	15-151294-000-00-RS	4/17/15	4/17/15	934 SE REX ST	97202	single family		X
27	14-248732-000-00-RS	12/12/14	4/21/15	5036 N ALBINA AVE	97217	single family		X
28	15-122338-000-00-RS	2/20/15	4/3/15	7134 N RICHMOND AVE	97203	single family		X
29	15-122529-000-00-RS	2/20/15	4/1/15	1435 NE 72ND AVE	97213	single family		X
30	15-117608-000-00-RS	4/21/15	4/21/01	7650 N DECATUR ST	97203	single family		X
31	14-255403-000-00-RS	4/1/15	4/1/15	5909 SW NEBRASKA ST	97221	single family		X
32	15-133345-000-00-RS	3/13/15	4/20/15	4813 SE BROOKLYN ST	97206	single family		x
33	15-143248-000-00-RS	4/2/15	4/2/15	3118 SE WOODWARD ST	97202	single family		x
34	15-105484-000-00-RS	1/16/15	4/2/15	5244 NE 32ND AVE	97211	single family		x
35	14-241038-000-00-RS	11/21/14	4/17/15	2246 NW PETTYGROVE ST	97210	single family		x
36	14-251552-000-00-RS	12/19/14	4/16/15	3355 SE 16TH AVE	97202	single family		x

				May				
1	15-169932-000-00-CO	5/13/15	5/13/15	311 SE 97TH AVE	97216	Apartments (4 Plex)	X	
2	14-218003-000-00-CO	9/26/14	5/18/15	3823 NE GLISAN ST	97232	Assembly (Church)	X	
3	14-182266-000-00-CO	5/8/15	5/8/15	1953 NW OVERTON ST	97209	BUSINESS	X	
4	13-208960-000-00-CO	9/24/13	5/12/15	5025 NE 101ST AVE	97220	Mercantile (conv. Store)	X	
5	15-167426-000-00-CO	5/8/15	5/18/15	9111 NE HALSEY ST	97220	storage	x	
6	15-163404-000-00-CO	5/1/15	5/1/15	611 SW KINGSTON AVE		storage sheds		
7	15-167401-000-00-CO	5/8/15	5/18/15	1505 NE 92ND AVE	97220	utility		
8	15-154922-000-00-RS	4/22/15	5/28/15	7340 N MACRUM AVE	97203	single family	x	
9	15-150944-000-00-RS	4/17/15	5/29/15	2602 NE 13TH AVE	97212	single family		x
10	15-153183-000-00-RS	4/21/15	5/27/15	820 NE 69TH AVE	97213	single family		x
11	14-171398-000-00-RS	3/17/15	5/27/15	8249 SE BUSH ST	97266	single family		x
12	15-153166-000-00-RS	4/21/15	5/27/15	1721 NE HIGHLAND ST	97211	single family		x
13	15-127808-000-00-RS	4/14/15	5/27/15	10923 NE FREMONT ST	97220	single family		x
14	15-143141-000-00-RS	4/1/15	5/26/15	3810 SE 69TH AVE	97206	single family		x
15	15-144620-000-00-RS	4/14/15	5/26/15	25 SE 143RD AVE	97233	single family		x
16	15-144591-000-00-RS	4/14/15	5/26/15	14232 E BURNSIDE ST	97233	single family		x
17	15-144608-000-00-RS	4/14/15	5/26/15	14238 E BURNSIDE ST	97233	single family		x
18	15-150830-000-00-RS	4/17/15	5/26/15	258 SW HUMPHREY BLVI	97221	single family		x
19	15-100701-000-00-RS	1/6/15	5/22/15	6108 SE STEELE ST	97206	single family		x
20	15-146571-000-00-RS	4/8/15	5/18/15	12036 SE PINE ST	97216	single family		x
21	14-251632-000-00-RS	12/19/14	5/18/15	7912 NE SCHUYLER ST	97213	single family		x
22	15-146489-000-00-RS	4/9/15	5/18/15	3914 N GANTENBEIN AVE	97227	single family		x
23	15-136643-000-00-RS	3/19/15	5/15/15	727 SE 130TH AVE	97233	single family		x
24	15-143715-000-00-RS	4/2/15	5/14/15	4723 NE 13TH AVE	97211	single family		x
25	15-169939-000-00-RS	5/13/15	5/13/15	301 SE 97TH AVE	97216	single family		x
26	09-136539-000-00-RS	6/17/09	5/13/15	5327 N VANCOUVER AVE	97217	?		
27	14-240241-000-00-RS	11/20/14	5/12/15	7604 SE CLAY ST	97215	single family		X
28	15-135087-000-00-RS	3/17/15	5/11/15	4425 SE 72ND AVE	97206	single family		X
29	15-144737-000-00-RS	4/3/15	5/11/15	6419 SE RAMONA ST	97206	5+ unit		X
30	15-140942-000-00-RS	3/27/15	5/7/15	5804 NE 11TH AVE	97211	single family		X
31	14-254162-000-00-RS	12/29/14	5/15/15	340 NE KILLINGSWORTH S	97211	single family		X
32	14-244625-000-00-RS	12/3/14	5/14/15	1924 SE 50TH AVE	97215	single family		x
33	15-139715-000-00-RS	3/25/15	5/4/15	6903 SE HAROLD ST	97206	single family		x
34	15-138392-000-00-RS	3/23/15	5/1/15	6708 SE RAMONA ST	97206	single family		X

				June				
1	15-132586-000-00-CO	3/20/15	6/19/15	6941 N CENTRAL ST	97203	assembly (boiler bldg)	x	
2	15-129733-000-00-CO	3/20/15	6/12/15	5405 SE WOODWARD ST	97206	gymnasium	X	
3	15-177660-000-00-CO	6/1/15	6/1/15	5235 NE 112TH AVE	97220		X	
4	15-180130-000-00-CO	6/9/15	6/9/15	2010 NW PETTYGROVE ST	97209	Office Building	x	
5	15-188109-000-00-CO	6/18/15	6/18/15	5711 E BURNSIDE ST	97213	commercial	x	
6	15-129735-000-00-CO	3/20/15	6/12/15	5405 SE WOODWARD ST	97206	shop bldg	x	
7	15-193874-000-00-CO	6/29/15	6/29/15	411 SE 14TH AVE	97214	commercial	x	
8	15-193880-000-00-CO	6/29/15	6/29/15	411 SE 14TH AVE	97214	commercial	x	
9	15-118590-000-00-CO	3/10/15	6/22/15	8448 NE 33RD DR		storage	x	
10	15-164067-000-00-RS	5/4/15	6/23/15	7217 SW VIRGINIA AVE	97219	duplex		x
11	15-164071-000-00-RS	5/4/15	6/23/15	7219 SW VIRGINIA AVE	97219	duplex		x
12	15-164059-000-00-RS	5/4/15	6/23/15	7221 SW VIRGINIA AVE	97219	duplex		x
13	15-163942-000-00-RS	5/4/15	6/30/15	959 NW MONTE VISTA TE	97210	single family		x
14	15-162088-000-00-RS	5/4/15	6/26/15	4833 NE 18TH AVE	97211	single family		x
15	15-172234-000-00-RS	5/18/15	6/25/15	7405 SE 64TH AVE	97206	single family		x
16	15-172188-000-00-RS	5/18/15	6/24/15	3037 SE PINE ST	97214	single family		x
17	15-172180-000-00-RS	5/18/15	6/24/15	4942 NE 35TH AVE	97211	single family		x
18	15-170015-000-00-R	5/15/15	6/24/15	3116 N VANCOUVER AVE	97227	single family		x
19	15-171739-000-00-RS	5/15/15	6/24/15	5624 SE 22ND AVE	97202	single family		x
20	15-165634-000-00-RS	5/6/15	6/19/15	4233 SE YAMHILL ST	97215	single family		x
21	15-154951-000-00-RS	4/22/15	6/19/15	1939 SW IOWA ST	97201	single family		x
22	15-161139-000-00-RS	4/29/15	6/18/15	3738 SE NEHALEM ST	97202	single family		x
23	15-166493-000-00-RS	5/7/15	6/16/15	1807 N KILPATRICK ST	97217	single family		x
24	15-160553-000-00-RS	5/1/15	6/16/15	8952 N FORTUNE AVE	97203	single family		x
25	15-165129-000-00-RS	5/8/15	6/15/15	10931 SW 61ST AVE	97219	single family		x
26	15-150921-000-00-RS	4/17/15	6/12/15	5834 N MISSISSIPPI AVE	97217	single family		x
27	15-160486-000-00-RS	5/1/05	6/11/15	750 NE 94TH AVE	97220	single family		x
28	15-163615-000-00-RS	5/1/15	6/10/15	4060 SE MALL ST	97202	single family		x
29	15-156199-000-00-RS	4/2/15	6/10/15	1525 NE ROSA PARKS WA	97211	single family		x
30	15-164079-000-00-RS	5/4/15	6/9/15	4123 N MICHIGAN AVE	97217	single family		x
31	15-159588-000-00-RS	4/27/15	6/5/15	3841 SE 150TH AVE	97236	single family		x
32	15-156076-000-00-RS	4/27/15	6/4/15	6320 SE CARLTON ST	97206	single family		x
33	14-216483-000-00-RS	9/23/14	6/2/15	4541 N WILLIAMS AVE	97211	single family		x
34	15-156145-000-00-RS	4/24/15	6/4/15	4821 SE BROOKLYN ST	97206	single family		x

				July				
1	15-195245-000-00-CO	7/1/15	7/1/15	4920 SW LANDING DR	97201	commercial	x	
2	15-197390-000-00-CO	7/7/15	7/7/15	1685 SE UMATILLA ST	97202	commercial	x	
3	15-197161-000-00-CO	7/10/15	7/10/15	1240 NE 122ND AVE	97230	commercial	x	
4	15-210275-000-00-CO	7/31/15	7/31/15	821 NW EVERETT ST	97209	commercial	x	
5	15-210264-000-00-CO	7/31/15	7/31/15	303 NW PARK AVE	97209	commercial	x	
6	15-210282-000-00-CO	7/31/15	7/31/15	338 NW 9TH AVE	97209	commercial	x	
7	15-200509-000-00-CO	7/13/15	7/13/15	5617 NE PORTLAND HWY	97218	commercial	x	
8	15-183262-000-00-RS	6/9/15	7/31/15	2834 SE 20TH AVE	97202	single family		x
9	15-209652-000-00-RS	7/31/15	7/31/15	8 SE CRYSTAL SPRINGS B	97206	single family		x
10	15-175055-000-00-RS	5/22/15	7/1/15	3930 NE 20TH AVE	97212	single family		x
11	15-174826-000-00-RS	5/22/15	7/2/15	2025 N ALBERTA ST	97217	single family		x
12	15-178253-000-00-RS	6/1/15	7/7/15	10945 SW 64TH AVE	97219	single family		x
13	15-168069-000-00-RS	6/3/15	7/9/15	3106 SE CLINTON ST	97202	single family		x
14	15-171360-000-00-RS	5/15/15	7/10/15	3015 SW IDAHO ST	97201	single family		x
15	15-170016-000-00-RS	5/13/15	7/10/15	3934 NE 66TH AVE	97213	single family		x
16	15-180063-000-00-RS	6/3/15	7/10/15	3110 SE FRANCIS ST	97202	single family		x
17	15-177676-000-00-RS	5/29/15	7/10/15	3731 SE FLAVEL ST	97202	single family		x
18	15-151283-000-00-RS	4/20/15	7/13/15	4922 NE GOING ST	97218	single family		x
19	15-142489-000-00-RS	4/1/15	7/13/15	2736 N HUNT ST	97217	single family		x
20	15-180114-000-00-RS	6/8/15	7/14/15	5048 NE 8TH AVE - Unit A		single family		x
21	15-181388-000-00-RS	6/5/15	7/14/15	4110 SE CLINTON ST	97202	single family		X
22	15-181224-000-00-RS	6/5/15	7/15/15	625 N PORTSMOUTH AV	97203	single family		X
23	15-181344-000-00-RS	6/5/15	7/15/15	406 N WILLAMETTE BLVD	97203	single family		X
24	15-181316-000-00-RS	6/5/15	7/15/15	308 N WILLAMETTE BLVD	97203	single family		X
25	15-181335-000-00-RS	6/5/15	7/15/15	316 N WILLAMETTE BLVD	97203	single family		x
26	15-181176-000-00-RS	6/5/15	7/15/15	605 N PORTSMOUTH AV	97203	single family		x
27	15-181460-000-00-RS	6/5/15	7/15/15	414 N WILLAMETTE BLVD	97203	single family		X
28	15-125327-000-00-RS	3/3/15	7/15/15	4512 NE 26TH AVE	97211	single family		X
29	15-173105-000-00-RS	5/27/15	7/16/15	1414 SE FRANKLIN ST	97202	single family		X
30	15-182220-000-00-RS	6/8/15	7/16/15	109 NE 42ND AVE, 9723	97232	single family		X
31	15-150819-000-00-RS	4/17/15	7/20/15	4270 SW MELVILLE AVE	97201	single family		X
32	15-192008-000-00-RS	7/20/15	7/20/15	4909 SE MITCHELL ST	97206	single family		x
33	15-186083-000-00-RS	6/15/15	7/22/15	9022 NE IRVING ST	97220	single family		x
34	15-186072-000-00-RS	6/15/15	7/22/15	4319 N BORTHWICK AVE	97217	single family		x
35	15-175746-000-00-RS	5/28/15	7/22/15	5626 NE 30TH AVE	97211	single family		x
36	15-182998-000-00-RS	6/9/15	7/23/15	7333 N WESTANNA AVE	97203	single family		x
37	15-186036-000-00-RS	6/16/15	7/23/15	2115 SE 44TH AVE	97215	single family		x
38	15-183752-000-00-RS	6/10/15	7/24/15	1806 N ALBERTA ST	97217	single family		x
39	15-174896-000-00-RS	5/28/15	7/24/15	6716 N BORTHWICK AVE	97217	single family		x
40	15-187711-000-00-RS	6/17/15	7/27/15	6608 SE 43RD AVE	97206	single family		x
41	15-186858-000-00-RS	6/17/15	7/27/15	2224 SE 32ND PL	97214	single family		x
42	15-184516-000-00-RS	6/19/15	7/30/15	9105 NE SACRAMENTO ST	97220	single family		x

				August				
1	15-213193-000-00-CO	8/7/15	8/7/15	423 SE HAWTHORNE BLV	97214	apartments		x
2	15-227598-000-00-CO	8/28/215	8/28/15	3029 SE FRANKLIN ST	97202	triplex apartments		x
3	15-215012-000-00-CO	8/10/15	8/10/15	1437 SW BROADWAY	97201	2 story commercial	x	
4	15-119430-000-00-CO	3/27/15	8/31/15	1362 NW NAITO PKY	97209	warehouse storage	x	
5	15-213221-000-00-CO	8/7/15	8/7/15	811 SE STARK ST	97214	commercial	x	
6	15-216966-000-00-CO	8/12/15	8/12/15	1551 SW TAYLOR ST	97205	commercial	x	
7	15-207290-000-00-CO	8/18/15	8/18/15	1831 NW 28TH AVE	97210	commercial	x	
8	15-196400-000-00-RS	7/6/15	8/11/15	518 SE DIVISION ST, 972	97206	duplex		x
9	15-196394-000-00-RS	7/6/15	8/12/15	6930 NE 15TH AVE	97211	duplex		x
10	15-151367-000-00-RS	4/17/15	8/25/15	7980 SE 6TH AVE	97202	single family		x
11	15-177683-000-00-RS	5/29/15	8/25/15	3416 NE ALAMEDA ST	97212	single family		X
12	15-175623-000-00-RS	5/26/15	8/25/15	5049 SW NEVADA CT	97219	single family		X
13	15-181581-000-00-RS	6/8/15	8/26/15	4511 SE MADISON ST	97215	single family		X
14	15-125101-000-00-RS	2/26/15	8/27/15	203 N HOLLAND ST	97217	single family		X
15	15-151395-000-00-RS	4/17/15	8/28/15	7524 SE LONG ST	97206	single family		x
16	15-227766-000-00-RS	8/31/15	8/31/15	2658 NW THURMAN ST	97210	single family		x
17	15-151322-000-00-RS	4/17/15	8/25/15	7974 SE 6TH AVE	97202	single family		x
18	15-200442-000-00-RS	7/13/15	8/24/15	5012 SE 50TH AVE	97206	single family		x
19	15-202965-000-00-RS	7/17/15	8/24/15	10020 NE PACIFIC ST	97220	single family		x
20	15-186808-000-00-RS	6/16/15	8/21/15	6223 SE TOLMAN ST	97206	single family		x
21	14-246239-000-00-RS	12/5/15	8/21/15	4065 N MICHIGAN AVE	97227	single family		x
22	15-201831-000-00-RS	7/15/15	8/20/15	6524 NE GRAND AVE	97211	single family		x
23	15-199260-000-00-RS	7/10/15	8/19/15	5414 SE TAYLOR ST	97215	single family		x
24	15-199731-000-00-RS	7/13/15	8/19/15	2024 SE HAROLD ST	97202	single family		x
25	15-175558-000-00-RS	5/26/15	8/18/15	5030 SE HAROLD ST	97206	single family		x
26	15-219786-000-00-RS	8/18/15	8/18/15	7834 SE TAYLOR ST	97215	single family		x
27	15-165609-000-00-RS	5/6/15	8/18/15	8330 SW 45TH AVE	97219	single family		x
28	15-168486-000-00-RS	5/11/15	8/18/15	8052 N JERSEY ST	97203	single family		x
29	15-197102-000-00-RS	7/7/15	8/17/15	4842 SE OGDEN ST	97206	single family		x
30	15-172453-000-00-RS	5/18/15	8/14/15	4021 NE 7TH AVE	97212	single family		x
31	15-163229-000-00-RS	5/1/15	8/14/15	625 NE RANDALL AVE	97232	single family		x
32	15-193721-000-00-RS	7/1/15	8/13/15	3207 SE WASHINGTON S	97233	single family		x
33	15-166488-000-00-RS	5/7/15	8/11/15	3030 SE REX ST	97202	single family		x
34	15-195412-000-00-RS	7/2/15	8/7/15	4015 SW ALICE ST	97219	single family		x
35	15-195431-000-00-RS	7/2/15	8/7/15	9221 SW 40TH AVE	97219	single family		x
36	15-194122-000-00-RS	6/30/15	8/6/15	1450 SW JEFFERSON ST	97201	single family		X
37	15-194183-000-00-RS	6/30/15	8/5/15	7850 SW 30TH AVE	97219	single family		X
38	15-194213-000-00-RS	6/30/15	8/15/15	8514 SW 46TH AVE	97219	single family		X
39	15-191206-000-00-RS	6/24/15	8/4/15	2727 NE BRAZEE CT	97212	single family		X
40	15-227746-000-00-RS	8/31/15	8/31/15	2652 NW THURMAN ST	97210	single family		X
41	15-148920-000-00-RS	5/11/15	8/3/15	4506 SW ORMANDY WA	97221	single family		X

				September				
1	15-237380-000-00-CO	9/16/15/	9/16/15	4537 NE FREMONT ST	97213	restaurant	x	
2	15-210014-000-00-CO	9/29/15	9/29/01	1626 NE 9TH AVE	97232	school	x	
3	15-232377-000-00-CO	9/4/15	9/4/15	2330 NW RALEIGH ST	97210	factory/industrial	x	
4	15-132872-000-00-CO	3/17/15	9/25/15	810 N FREMONT ST	97227	storage	x	
5	15-210048-000-00-RS	7/31/15	9/23/15	8500 SE SHERRETT ST	97266	single family		x
6	15-214853-000-00-RS	8/10/15	9/23/15	7471 N HURON AVE	97203	single family		x
7	15-207779-000-00-RS	7/28/15	9/23/15	4160 SW PATRICK PL	97201	single family		x
8	15-219786-000-00-RS	8/18/15	9/23/15	7834 SE TAYLOR ST	97215	single family		x
9	15-214987-000-00-RS	8/11/15	9/18/15	7345 SW 54TH AVE	97219	single family		x
10	15-214991-000-00-RS	8/11/15	9/18/15	7339 SW 54TH AVE	97219	single family		x
11	15-216725-000-00-RS	8/12/15	9/18/15	7933 N COURTENAY AVE	97203	single family		x
12	15-235904-000-00-RS	9/16/15	9/16/15	4525 NE FREMONT ST	97213	single family		x
13	15-235887-000-00-RS	9/16/15	9/16/15	4515 NE FREMONT ST	97213	single family		x
14	15-206999-000-00-RS	7/27/15	9/16/15	1017 SE 50TH AVE	97215	single family		x
15	15-211673-000-00-RS	8/6/15	9/15/15	2821 N WILLIS BLVD	97217	single family		x
16	15-211351-000-00-RS	8/4/15	9/15/15	4005 SE LAMBERT ST	97202	single family		x
17	15-234254-000-00-RS	9/10/15	9/10/15	7627 SE MILWAUKIE AVE	97202	single family		x
18	15-211665-000-00-RS	8/4/15	9/9/15	5025 N AMHERST ST	97203	single family		x
19	15-181327-000-00-RS	6/5/15	9/9/15	3215 NE 42ND AVE	97212	single family		x
20	15-209617-000-00-RS	7/31/15	9/9/15	2602 N TERRY ST	97217	single family		x
21	15-199303-000-00-RS	7/10/15	9/9/15	920 NE SUMNER ST	97211	single family		x
22	15-208252-000-00-RS	7/28/15	9/4/15	1554 NE 74TH AVE	97213	single family		x
23	15-195677-000-00-RS	7/2/15	9/4/15	1221 SE MALDEN ST	97202	single family		x
24	15-210278-000-00-RS	7/31/15	9/25/15	9232 N SMITH ST	97203	single family		x
25	15-170043-000-00-RS	5/13/15	9/4/15	5252 NE MULTNOMAH ST	97213	single family		x

				October				
1	15-245720-000-00-CO	10/9/15	10/9/15	10721 NE SANDY BLVD	97220	mercantile	x	
2	15-256511-000-00-CO	10/26/15	10/26/15	431 NW 9TH AVE	97209	storage	x	
3	15-238039-000-00-RS	9/18/15	10/29/15	3945 NE MALLORY AVE	97212	single family		x
4	15-240274-000-00-RS	9/22/15	10/29/15	9138 N VAN HOUTEN AVE	97203	single family		x
5	13-129119-000-00-RS	3/19/13	10/30/15	1136 SE OAK ST	97214	single family		x
6	15-219255-000-00-RS	8/18/15	10/28/15	623 NE THOMPSON ST	97212	single family		x
7	15-219268-000-00-RS	8/18/15	10/28/15	633 NE THOMPSON ST	97212	single family		x
8	15-233525-000-00-RS	9/9/15	10/26/15	6414 NE 34TH AVE	97211	single family		x
9	15-227440-000-00-RS	8/28/15	10/23/15	4826 N MISSOURI AVE	97212	single family		x
10	15-222484-000-00-RS	8/21/15	10/23/15	5605 SE 67TH AVE	97206	single family		x
11	15-235736-000-00-RS	9/14/15	10/23/15	343 NE 75TH AVE	97214	single family		x
12	15-178470-000-00-RS	6/1/15	10/23/15	6005 NE 6TH AVE	97211	single family		x
13	15-235262-000-00-RS	9/15/15	10/22/15	4224 SE 101ST AVE		single family		x
14	15-236125-000-00-RS	9/14/15	10/21/15	12320 SE REEDWAY ST	97236	single family		x
15	15-232742-000-00-RS	9/8/15	10/21/15	3721 SE NEHALEM ST	97202	single family		x
16	15-253065-000-00-RS	10/21/15	10/21/15	4005 NE COLUMBIA BLVD	97211	single family		x
17	15-215447-000-00-RS	8/11/15	10/21/15	1307 NE 111TH AVE	97220	single family		x
18	15-204611-000-00-RS	7/21/15	10/20/15	5403 NE 17TH AVE	97211	single family		x
19	15-204598-000-00-RS	7/21/15	10/20/15	5329 NE 17TH AVE	97211	single family		x
20	15-234271-000-00-RS	9/10/15	10/16/15	342 NE 74TH AVE	97213	single family		x
21	15-232949-000-00-RS	9/8/16	10/16/15	5903 SE KNIGHT ST	97206	single family		x
22	15-228311-000-00-RS	8/31/15	10/16/15	5236 SE HENDERSON ST	97206	single family		x
23	15-232666-000-00-RS	9/8/15	10/15/15	1535 NE JARRETT ST	97211	single family		x
24	15-229647-000-00-RS	9/1/15	10/14/15	7715 SE 22ND AVE	97202	single family		x
25	15-227491-000-00-RS	9/4/15	10/13/15	7104 N KERBY AVE	97217	single family		x
26	15-230543-000-00-RS	9/2/15	10/8/15	2410 NE REGENTS DR	97217	single family		x
27	15-196491-000-00-RS	7/6/15	10/8/15	3731 SE NEHALEM ST	97202	single family		x
28	15-181333-000-00-RS	6/8/15	10/5/15	9004 SE STEELE ST	97266	single family		x
29	15-175524-000-00-RS	5/26/15	10/5/15	3403 NE 76TH AVE	97213	single family		x
30	15-243575-000-00-RS	10/2/15	10/2/15	1640 SE TACOMA ST	97202	single family		x
31	15-243483-000-00-RS	10/2/15	10/2/15	1926 NE MASON ST	97212	single family		x

				November				
1	15-251903-000-00-CO	11/6/15	11/6/15	2913 SE STARK ST	97214	restaurant	x	
2	15-259283-000-00-CO	11/4/15	11/4/15	7434 N CHARLESTON AVE	97203	church	x	
3	15-259271-000-00-CO	11/4/15	11/4/15	8221 N LOMBARD ST	97203	business	x	
4	15-259275-000-00-CO	11/4/15	11/4/15	8247 N LOMBARD ST	97203	business	x	
5	15-266654-000-00-RS	11/23/15	11/23/15	1515 SE 44TH AVE	97215	single famikly		x
6	15-245856-000-00-RS	10/2/15	11/24/15	5919 NE 11TH AVE	97211	single famikly		x
7	15-243625-000-00-RS	9/29/15	11/24/15	1722 NE LIBERTY ST	97211	single famikly		x
8	15-230603-000-00-RS	9/4/15	11/25/15	8205 SE 69TH AVE	97206	single famikly		x
9	15-266665-000-00-RS	11/19/15	11/19/15	334 SE HAWTHORNE BLV	97215	single famikly		x
10	15-232942-000-00-RS	9/8/15	11/19/15	3535 SW LOGAN ST	97219	single famikly		x
11	15-151329-000-00-RS	4/17/15	11/8/15	524 NE 128TH AVE		single famikly		x
12	15-250111-000-00-RS	10/13/15	11/17/15	935 N WEBSTER ST	97217	single famikly		x
13	15-230746-000-00-RS	10/12/15	11/17/15	4805 NE GARFIELD AVE	97211	single famikly		x
14	15-247517-000-00-RS	10/7/15	11/16/15	3935 NE RODNEY AVE	97212	single famikly		x
15	15-247475-000-00-RS	10/8/15	11/13/15	1410 NE JUNIOR ST	97211	single famikly		x
16	15-247511-000-00-RS	10/7/15	11/13/15	3925 NE RODNEY AVE	97212	single famikly		x
17	15-246608-000-00-RS	10/6/15	11/13/15	5747 SE CARLTON ST	97206	single famikly		x
18	15-241527-000-00-RS	9/24/15	11/12/15	920 SE TACOMA ST	97202	single famikly		x
19	15-237880-000-00-RS	9/18/15	11/12/15	5110 SE 111TH AVE	97266	single famikly		x
20	15-240283-000-00-RS	9/22/15	11/10/15	1724 N SUMNER ST	97217	single famikly		x
21	15-242909-000-00-RS	9/28/15	11/4/15	3679 SE KNAPP ST	97202	single famikly		x
22	15-259973-000-00-RS	11/4/15	11/4/15	7434 N CHARLESTON AVE	97203	single famikly		x
23	15-207009-000-00-RS	7/27/15	11/2/15	5205 NE 25TH AVE	97211	single famikly		x
24	15-244127-000-00-RS	10/21/15	11/30/15	2486 NW RALEIGH ST	97210	single famikly		x
25	15-228507-000-00-RS	9/1/15	11/2/15	10345 SE RAMONA ST	97266	single famikly		x
26	15-240267-000-00-RS	9/22/15	11/2/15	6025 SE LAMBERT ST	97206	single famikly		x

				December				
1	15-193736-000-00-CO	12/16/15	12/16/15	6941 N CENTRAL ST	97203	assembly	x	
2	15-275272-000-00-CO	12/10/15	12/10/15	200 SE MILWAUKIE AV	97202	business	x	
3	15-274928-000-00-CO	12/9/15	12/9/15	1900 NE M L KING BLVD	97212	business	x	
4	15-282059-000-00-CO	12/29/15	12/29/15	2270 NW GLISAN ST	97210	business	x	
5	15-275807-000-00-CO	12/21/15	12/21/15	818 SE 6TH AVE	97214	business	x	
6	15-240438-000-00-CO	9/29/15	12/23/15	6504 NE 29TH AVE	97211	business	x	
7	15-187851-000-00-CO	6/26/15	12/4/15	135 NW 9TH AVE	97209	business	x	
8	15-269170-000-00-CO	12/4/15	12/4/15	413 N INTERSTATE AV	97212	business	x	
9	15-282045-000-00-CO	12/29/15	12/29/15	2280 NW GLISAN ST	97210	business	x	
10	15-240498-000-00-CO	9/29/15	12/23/15	2930 NE DEKUM ST	97211	school	x	
11	15-203916-000-00-CO	7/24/15	12/28/15	5205 SE 86TH AVE	97266	school	x	
12	15-203900-000-00-CO	7/24/15	12/28/15	5205 SE 86TH AVE	97266	school	x	
13	15-193744-000-00-CO	12/16/15	12/16/15	6941 N CENTRAL ST	97203	school	x	
14	15-193725-000-00-CO	12/16/15	12/16/15	6941 N CENTRAL ST	97203	school	x	
15	15-270482-000-00-CO	12/1/15	12/1/15	535 NW 11TH AVE	97209	school	x	
16	15-277932-000-00-CO	12/16/15	12/16/15	3610 SE 29TH AVE	97202	warehouse	x	
17	15-278354-000-00-CO	12/17/15	12/17/15	2837 SE 17TH AVE	97202	warehouse	x	
18	15-277923-000-00-CO	12/16/15	12/16/15	3612 SE 29TH AVE	97202	warehouse	x	
19	15-252499-000-00-RS	12/17/15	12/17/15	1208 SE ANKENY ST	97214	duplex		x
20	15-257565-000-00-RS	10/28/15	12/4/15	846 N GREENWICH AV	97217	single family house		x
21	15-253825-000-00-RS	10/21/15	12/23/15	4439 N WILLIS BLVD	97203	single family house		x
22	15-256345-000-00-RS	10/26/15	12/3/15	2581 NE 30TH AVE	97212	single family house		x
23	15-260567-000-00-RS	11/4/15	12/23/15	5117 SE CORA ST	97206	single family house		x
24	15-262608-000-00-RS	11/10/15	12/30/15	5030 NE 28TH AVE	97211	single family house		X
25	15-258715-000-00-RS	10/30/15	12/11/15	3836 SE 26TH AVE	97202	single family house		X

26	15-259304-000-00-RS	11/2/15	12/18/15	8515 SE 21ST AVE	97202	single family house		X
27	15-260105-000-00-RS	11/4/15	12/15/15	5610 N GREELEY AVE	97217	single family house		x
28	15-260566-000-00-RS	11/4/15	12/11/15	6305 NE 27TH AVE	97211	single family house		X
29	15-267963-000-00-RS	11/20/15	12/30/15	5810 SE REEDWAY ST	97206	single family house		X
30	15-269921-000-00-RS	12/1/15	12/1/15	904 SW GIBBS ST	97201	single family house		X
31	15-269933-000-00-RS	12/1/15	12/1/15	836 SW GIBBS ST	97201	single family daylighbsm nt		x
32	15-280370-000-00-RS	12/22/15	12/22/15	21340 NW WATSON RD	97506	single family house		x
33	15-257553-000-00-RS	10/28/15	12/4/15	6856 N GREENWICH AVE	97217	single family house		x
34	15-252406-000-00-RS	10/9/15	12/1/15	1201 NE HOLLAND ST	97211	single family house		x
35	15-251343-000-00-RS	10/16/15	12/28/15	3344 SW PALATINE ST	97219	single family house		x
36	15-250940-000-00-RS	10/21/15	12/3/15	3942 NE 76TH AVE	97213	single family house		x
37	15-249395-000-00-RS	10/12/15	12/15/15	5018 SE CARLTON ST	97206	single family house		x
38	15-246297-000-00-RS	10/5/15	12/4/15	8226 SE 63RD AVE	97206	single family house		x
39	15-250239-000-00-RS	10/13/15	12/14/15	5729 N ALBINA AVE	97217	single family house		x
40	15-248021-000-00-RS	10/8/15	12/15/15	6325 SE 48TH AVE	97206	single family house		x
41	15-241419-000-00-RS	9/29/15	12/23/15	2937 NE ROSA PARKS WAY	97211	single family house		x
42	15-241417-000-00-RS	9/29/15	12/23/15	2925 NE ROSA PARKS WAY	97211	single family house		x
43	15-232167-000-00-RS	9/4/15	12/28/15	1416 SE CLATSOP ST	97202	single family house		x
44	15-223077-000-00-RS	8/21/15	12/30/15	3910 SE 34TH AVE	97202	single family house		x
45	15-227371-000-00-RS	8/28/15	12/10/15	4522 SE 41ST AVE	97202	single family house		x
46	15-220504-000-00-RS	10/19/15	12/28/15	1616 SE 87TH AVE	97216	single family house		x
47	15-209220-000-00-RS	7/29/15	12/3/15	3620 NE 43RD AVE	97213	single family house		x
48	15-208074-000-00-RS	7/28/15	12/2/15	2003 SE YAMHILL ST	97214	single family house		x
49	15-173393-000-00-RS	5/20/15	12/29/15	3505 N WILLIS BLVD	97217	single family house		x
50	15-254257-000-00-RS	10/21/15	12/3/15	4431 SW CORONADO ST	97219	single family house		x

B. Demolition permits issued in 2015 were categorized into single-family, multi-family and commercial.

Percent of Single Family

	Single Family Demolitions	
Month	Total Single Family	% of total
January	17	71%
February	31	86%
March	32	78%
April	26	72%
May	26	76%
June	22	65%
July	35	83%
August	32	78%
September	21	84%
October	29	94%
November	22	85%
December	31	62%

Percent of Multi-Family

	Multi Family Demolitions	
Month	Total Multi Family	% of total
January	1	4%
February	0	0%
March	1	2%
April	0	0%
May	2	6%
June	3	9%
July	0	0%
August	4	10%
September	0	0%
October	0	0%
November	0	0%
December	1	2%

Percent of Commercial

	Commercial Demolitions	
Month	Total Commercial	% of total
January	6	25%
February	5	14%
March	8	20%
April	10	28%
May	5	15%
June	9	26%
July	7	17%
August	5	12%
September	4	16%
October	2	6%
November	4	15%
December	18	36%

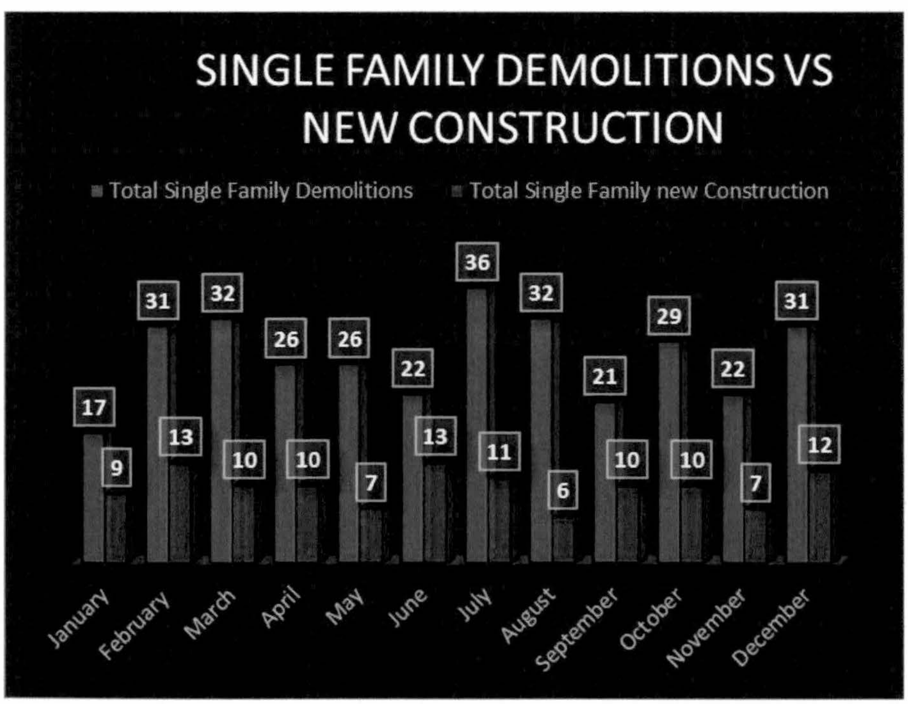
C. The total demolitions including all three categories was 420. The last column includes the total number of new single-family houses constructed.

Months	# of Demolitions	# of Single Family New Construction
January	24	9
February	36	13
March	41	11
April	36	10
May	34	7
June	34	13
July	42	11
August	41	6
September	25	10
October	31	10
November	26	7
December	50	12
	420	119

D. Total of single family homes demolished and new single family construction.

	Demolitions		New Construction vs Demolitions	
Month	Total Single Family	% of total	Total Single Family	% of total
January	17	71%	9	38%
February	31	86%	13	36%
March	32	78%	10	24%
April	26	72%	10	28%
May	26	76%	7	21%
June	22	65%	13	38%
July	35	83%	11	26%
August	32	78%	6	15%
September	21	84%	10	40%
October	29	94%	10	32%
November	22	85%	7	27%
December	31	62%	12	24%

E. Graph shows the existing to new single family construction. Blue column indicates existing single family houses demolished. Red columns indicate replacement single family houses.



F. Square footage of new single family home construction was calculated by month using Zillow.com and Google Maps. Carbon equivalency calculated using 25 kg/sq. ft. Pages 73-77.

Month	Square Footage	Carbon Equivalent	Square Foot of New Single Family House
January	1974	49350	**4 Beds 1,974 sq. ft.**
January	1956	48900	**3 beds 3 baths 1,956 sq. ft.**
January	2162	54050	**2 beds 2 baths 2,162 sq. ft.**
January	2972	74300	**3 beds 2.5 baths 2,972 sq. ft.**
January	2880	72000	**4 beds 2.5 baths 2,880 sq. ft.**
January	3081	77025	**4 Beds 2.5 Baths 3,081 sq. ft.**
January	2432	60800	**4 Beds 2.5 Baths 2,432 sq. ft.**
January	2814	70350	**2 beds 3.5 baths 2,814 sq. ft.**
January	2402	60050	**4 Beds 3 Baths 2,402 sq. ft.**
February	2531	63275	**4 beds 2.5 baths 2,531 sq. ft.**
February	3050	76250	**3 beds 4 baths 3,050 sq. ft.**
February	2361	59025	**4 beds 3 baths 2,361 sq. ft.**
February	2377	59425	**4 beds 3.5 baths 2,377 sq. ft.**
February	2335	58375	**3 Beds 3 Baths 2,335 sq. ft.**
February	1872	46800	**4 Beds 2.5 Baths 1,872 sq. ft.**
February	2832	70800	**4 beds 3 baths 2,832 sq. ft.**
February	2539	63475	**4 beds 3.5 baths 2,539 sq. ft.**
February	2408	60200	**4 beds 2 baths 2,408 sq. ft.**
February	2922	73050	**4 Beds 2.5 Baths 2,922 sq. ft.**
February	2902	72550	**4 beds 2.5 baths 2,902 sq. ft.**
February	2459	61475	**3 beds 2.1 baths 2,459 sq. ft.**
February	2241	56025	**4 beds 2.1 baths 2,241 sq. ft.**
March	2859	71475	**4 Bedroom 3 1/2 Bath 2859 sq. ft.**

March	3120	78000	**2 Beds 2.5 Baths 3,120 sq. ft.**
March	3228	80700	**4 Beds 2.5 Baths 3,228 sq. ft.**
March	2480	62000	**4 beds 3 baths 2,480 sq. ft.**
March	2432	60800	**4 beds 3 baths2,432 sq. ft.**
March	2878	71950	**3 beds 3 baths 2,878 sq. ft.**
March	2265	56625	**4 Beds 2.5 Baths 2,265 sq. ft.**
March	2112	52800	**3 Beds 1.5 Baths 2,112 sq. ft.**
March	1965	49125	**3 Beds 2.5 Baths 1,965 sq. ft.**
March	2526	63150	**4 Beds 2.5 Baths 2,526 sq. ft.**
April	2256	56400	**4 Beds 2.5 Baths 2,256 sq. ft.**
April	1445	36125	**1,445 sq. ft.**
April	1841	46025	**4 Beds 2.5 Baths 1,841 sq. ft.**
April	2375	59375	**4 Beds 2.5 Baths 2,375 sq. ft.**
April	1566	39150	**3 Beds 2.1 Ba 1,566 sq. ft.**
April	2000	50000	**3 bed 2.5 baths 2,000 sq. ft.**
April	2432	60800	**5 Beds 3.5 Baths 2,432 sq. ft.**
April	3067	76675	**4 Beds 3 Baths 3,067 sq. ft.**
April	3082	77050	**4 Beds 3 Baths 3,082s sq. ft.**
April	1689	42225	**3 Beds 2.5 Baths 1,689 sq. ft.**
May	2485	62125	**3 Beds 2.5 Baths 2,485 sq. ft.**
May	2150	53750	**2 Beds 2.5 Baths 2,150 sq. ft.**
May	2083	52075	**3 beds 3 baths 2,083 sq. ft.**
May	1570	39250	**3 beds 2.5 baths 1,570 sq. ft.**
May	2093	52325	**3 Beds 2.5 Baths 2,093 sq. ft.**
May	1589	39725	**3 Beds 2.5 Baths 1,589 sq. ft.**
May	1965	49125	**4 Beds 2.5 Baths 1,965 sq. ft.**

June	2724	68100	**3 Beds 2.5 Baths 2,724 sq. ft.**
June	1950	48750	**4 Beds 3.5 Baths 1,950 sq. ft.**
June	2818	70450	**4 Beds 3.5 Baths 2,818 sq. ft.**
June	2587	64675	**4 beds 3 baths 2,587 sq. ft.**
June	2463	61575	**3 Beds 2.5 Baths 2,463 sq. ft.**
June	2507	62675	**4 Beds 2.5 Baths 2,507 sq. ft.**
June	1922	48050	**3 Beds 3.5 Baths 1,922 sq. ft.**
June	2582	64550	**2 Beds 4 Baths 2,582 sq. ft.**
June	1586	39650	**3 beds 4.1 baths 1,586 sq. ft.**
June	2592	64800	**5 Beds 3 Baths 2,592 sq. ft.**
June	2728	68200	**3 Beds 2.5 Baths 2,728 sq. ft.**
June	1940	48500	**4 beds 2 baths 1,940 sq. ft.**
June	3310	82750	**4 beds 3 baths 3,310 sq. ft.**
July	2746	68650	**2 Beds 2.5 Baths 2,746 sq. ft.**
July	3141	78525	**5 Beds 3 Baths 3,141 sq. ft.**
July	2150	53750	**3 Beds 2.5 Baths 2,150 sq. ft.**
July	2008	50200	**3 beds 2.1 baths 2,008 sq. ft.**
July	2467	61675	**4 Beds 3 Baths 2,467 sq. ft.**
July	2967	74175	**5 Beds 2.5 Baths 2,967 sq. ft.**
July	2800	70000	**4 Beds 3.5 Baths 2,800 sq. ft.**
July	1764	44100	**3 Beds 2.5 Baths 1,764 sq. ft.**
July	3353	83825	**3 Beds 2.5 Baths 3,353 sq. ft.**
July	2578	64450	**4 Beds 2.5 Baths 2,578 sq. ft.**
July	2785	69625	**4 Beds 4 Baths 2,785 sq. ft.**
August	1949	48725	**4 beds 3 baths 1,949 sq. ft.**
August	2156	53900	**3 Beds 3 Baths 2,156 sq. ft.**

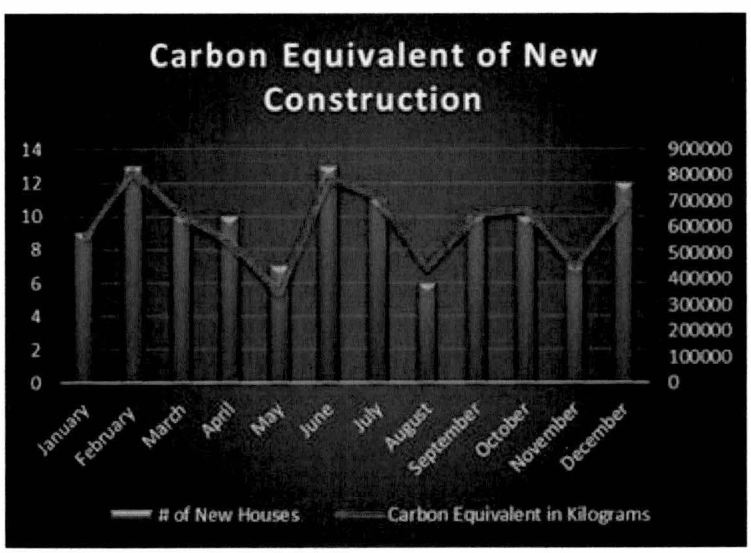
August	3050	76250	**4 Beds 2.5 Baths 3,050 sq. ft.**
August	3459	86475	**5 Beds 3.5 Baths 3,459 sq. ft.**
August	2540	63500	**3 Beds 3 Baths 2,540 sq. ft.**
August	4512	112800	**4 Beds 4.5 Baths 4,512 sq. ft.**
September	3680	92000	**4 beds 4 baths 3,680 sq. ft.**
September	2127	53175	**3 beds 2.5 baths 2,127 sq. ft.**
September	4135	103375	**4,153 3 Beds 3 Bathrooms sq. ft.**
September	2216	55400	**3 Beds 2.5 Baths 2,216 sq. ft.**
September	2237	55925	**3 beds 2.5 baths 2,237 sq. ft.**
September	3355	83875	**4 Beds 3 Baths 3,355 sq. ft.**
September	2467	61675	**4 Beds 3 Baths 2,467 sq. ft.**
September	2335	58375	**3 Beds 3 Baths 2,335 sq. ft.**
September	1593	39825	**3 Beds 2.5 Baths 1,593 sq. ft.**
September	1950	48750	**1 Bed 3.5 Baths 1,950 sq. ft.**
October	2161	54025	**4 Beds 3 Baths 2,161 sq. ft.**
October	2207	55175	**4 Beds 2.5 Baths 2,207 sq. ft.**
October	2631	65775	**5 Beds 2.5 Baths 2,631 sq. ft.**
October	2606	65150	**4 Beds 3.5 Baths 2,606 sq. ft.**
October	2591	64775	**4 Beds 3.5 Baths 2,591 sq. ft.**
October	1643	41075	**3 Beds 2.5 Baths 1,643 sq. ft.**
October	2491	62275	**4 Beds 3 Baths 2,491 sq. ft.**
October	2265	56625	**3 Beds 2.5 Baths 2,265 sq. ft.**
October	2888	72200	**4 Beds 2.5 Baths 2,888 sq. ft.**
October	5385	134625	**5 Beds 4 Baths 5,385 sq. ft.**

November	3131	78275	**4 Beds 2.5 Baths 3,131 sq. ft.**
November	2915	72875	**4 Beds 2 Baths 2915 sq. ft.**
November	2374	59350	**4 beds 2.5 baths 2,374 sq. ft.**
November	2280	57000	**3 Beds 2 Baths 2,280 sq. ft.**
November	3670	91750	**4 beds 3 baths 3,670 sq. ft.**
November	1555	38875	**2 beds 2 baths 1,555 sq. ft.**
November	1950	48750	**4 Beds 3 Baths 1,950 sq. ft.**
December	3409	85225	**4 beds 3 full baths 3,409 sq. ft.**
December	3488	87200	**5 beds 5 baths3,488 sq. ft.**
December	2911	72775	**5 Beds 3 Baths 2,911 sq. ft.**
December	2514	62850	**4 beds 2 baths 2,514 sq. ft.**
December	2578	64450	**4 Beds 2.5 Baths 2,578 sq. ft.**
December	3046	76150	**3 Beds 2.5 Baths 3,046 sq. ft.**
December	1412	35300	**3 Beds 2 Baths 1,412 sq. ft.**
December	1900	47500	**4 Beds 2.5 Baths 1,900 sq. ft.**
December	2410	60250	**4 Beds 2.5 Baths 2,410 sq. ft.**
December	1984	49600	**4 Beds 2.5 Baths 1,984 sq. ft.**
December	1865	46625	**3 beds 3 baths 1,865 sq. ft.**
December	2418	60450	**4 Beds 2.5 Baths 2,418 sq. ft.**
Average Square Foot	**2,508**	**7,399,050**	Total of Carbon Equivalent (kg)
Total Square Feet	**295,962**		

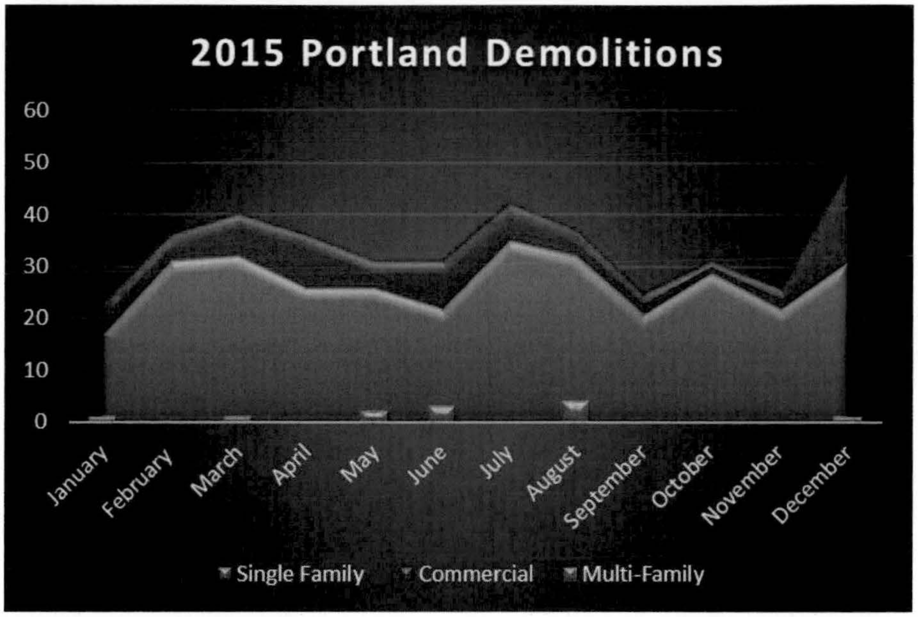
G. Total carbon equivalency (kg/CO2E) for new single family homes by month.

Month	# of New Houses	Carbon Equivalent in Kilograms
January	9	566825
February	13	820725
March	10	646625
April	10	543825
May	7	348375
June	13	792725
July	11	718975
August	6	441650
September	10	652375
October	10	671700
November	7	446875
December	12	687925

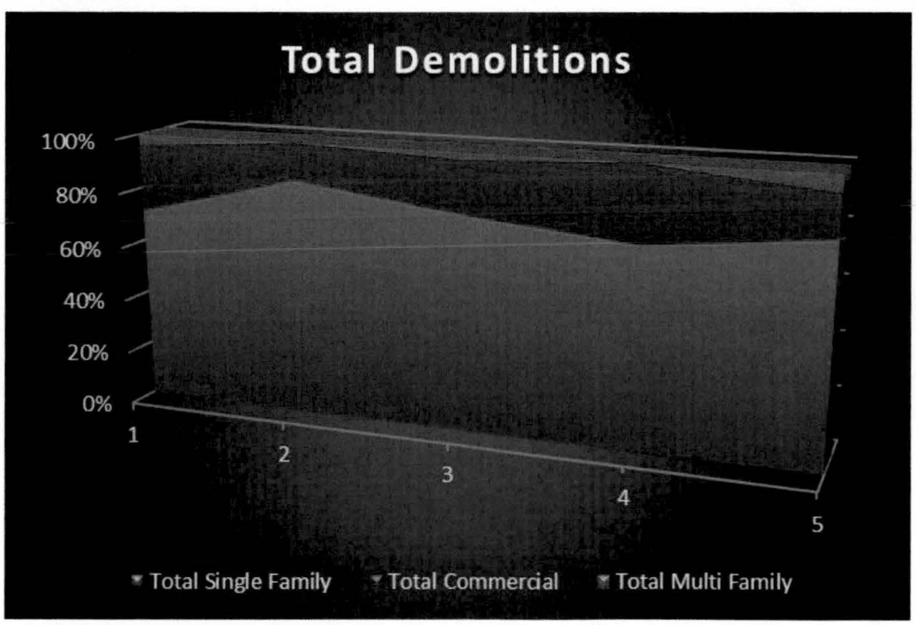
H. Graph representing the relationship between new single-family construction and carbon impacts, measured in carbon equivalency (kg).



I. Graph representing total demolitions including single-family, commercial and multi-family.



J. Total demolitions by percentage – single family houses were approximately 70% of all demolitions.



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Glossary of Commonly Used Terms

Embodied Energy

Energy used in raw material acquisition, production of materials, and the assemblage of those materials into a building.[82]

Global Warming Potential
Referred to as a "reference measure"[83], carbon dioxide is the common reference standard for global warming or greenhouse gas effects. All other greenhouse gases are referred to as having a "CO2 equivalence effect" which is simply a multiple of the greenhouse potential (heat trapping capability) of carbon dioxide. This effect has a time horizon due to the atmospheric reacitivty or stability of the various contributing gases over time. The International Panel on Climate Change (2001) 100-year time horizon figures have been used here as a basis for the equivalence index:

CO_2 Equivalent kg = CO_2 kg + (CH_4 kg x 23) + (N_2O kg x 296)

Life Cycle Assessment (LCA)
A science-based comparative analysis and assessment of the environmental impacts of product systems. Unlike other environmental impact systems LCA includes a 'cradle to grave' and 'functional unit' approach to assessing impacts.[84]

Operational Energy
Energy requirement of the building during its life from commissioning to demolition – this does not include renovations and maintenance.[85]

Primary Energy
Measured in Mega-joules (MJ), and includes all non-renewable energy, direct and indirect, used to transform or transport raw materials into products and buildings, including inherent energy contained in raw or feedstock materials that are also used as common energy sources – for example, natural gas used as a raw material in the production of various plastic (polymer) resins. In addition, the measure captures the pre-combustion (indirect) energy use associated with processing, transporting, converting and delivering fuel and energy. This measure provides a close approximation of the fossil fuel use.[86]

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[82] Jean Carroon and Richard Moe, *Sustainable Preservation: Greening Existing Buildings*, (Hoboken: Wiley, 2010), 7.
[83] Athena Sustainable Materials Institute, *User Manual and Transparent Document: Impact Estimator for Buildings v. 5*, (September, 2014), 46.
[84] Walter Klopfer, *The Background and Future Prospects of LCA*, (Springer Netherlands, 2014), 2.
[85] Richard Haynes, *Embodied Energy Calculations within Life Cycle Analysis of Residential Buildings*, 2013, 3.
[86] Athena Sustainable Materials Institute, Prepared for Parks Canada, *A Life Cycle Assessment Study of Embodied Energy Effects for Existing Historic Buildings*, (Canada: Athena Materials Institute, 2009), 4.