

# Dartmouth College Water Report

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FISCAL YEAR 2018



**DARTMOUTH**  
Sustainability Office

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# Dartmouth College Water Report

## Summary

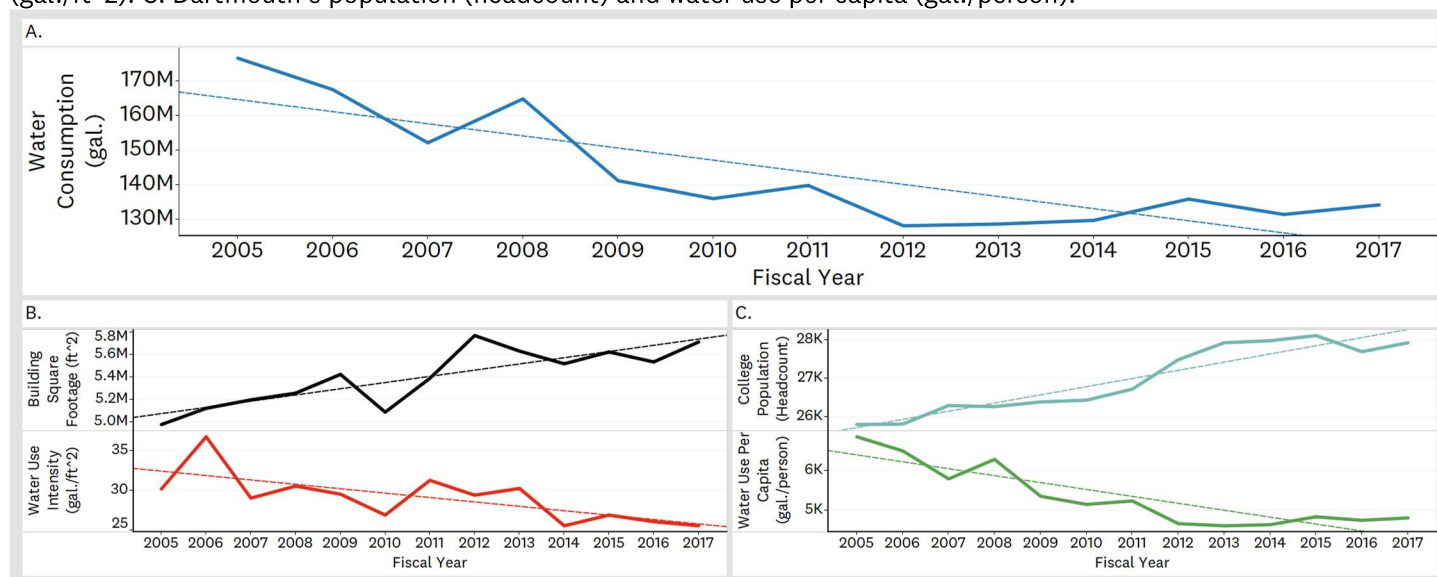
We evaluated the water consumption of 394 unique water meters (see Building Data Appendix) for college buildings and infrastructure in the Town of Hanover. We analyzed meter-level data beginning with the second quarter of fiscal year (FY) 2005 (Oct. 2004) to the end of fiscal year 2018 (July 2018). We also received the main campuses' water use as one lump sum for the first quarter of 2005. All data are reported in fiscal year; Dartmouth's fiscal year starts July 1<sup>st</sup> and ends June 30<sup>th</sup> the following year, e.g., fiscal year 2018 was July 1, 2017 to June 30, 2018.

Dartmouth's water consumption has significantly<sup>1</sup> ( $p < 0.01$ ) declined from 176.4M gal. in 2005 to 134.8M in 2018, a decrease of 41.7M gal or 24% (Fig. 1). We attribute the decline in Dartmouth's water consumption to a combination of factors including (i) energy efficiency projects that have resulted in 17.3M gal. saved at the Central Energy Plant (CEP) and the College's two chiller plants cumulatively, both of which use water to heat or cool buildings and (ii) building renovations such as those at the Hanover Inn and Class of 1953 Commons that now use 5.9M gal. cumulatively less than they did in 2005.

The College's building footprint (gross square footage), including its main campus and real estate holdings, has significantly ( $p < 0.01$ ) grown by approximately 800,000 square feet since 2005. The simultaneous decrease in water consumption and increase in the College's building stock has led to a significant ( $p < 0.01$ ) decline in water use intensity, i.e., the amount of water consumed per square foot of a building. Water-use intensity has declined 35% from over 10 gallons/ft<sup>2</sup> in 2005 to 6.5 gallons/ft<sup>2</sup> in 2018.

The College's population of students, staff, and faculty has significantly ( $p < 0.01$ ) grown by over 2,000 people from 25.8K people in 2005 to 27.9K in 2017. The simultaneous decrease in water consumption and increase in the College's population has led to a significant ( $p < 0.01$ ) decline in water use per capita, i.e., the average amount of water consumed by each person on campus. Water use per capita has declined 30% from over 6.8K gallons/person in 2005 to 4.8K gallons/person in 2018.

Figure 1. Dartmouth College's main campus and real estate buildings water summary for fiscal years 2005-2018. A. Dartmouth's water consumption (gal.). B. Dartmouth building's gross square footage (ft<sup>2</sup>) and water use intensity (gal./ft<sup>2</sup>). C. Dartmouth's population (headcount) and water use per capita (gal./person).



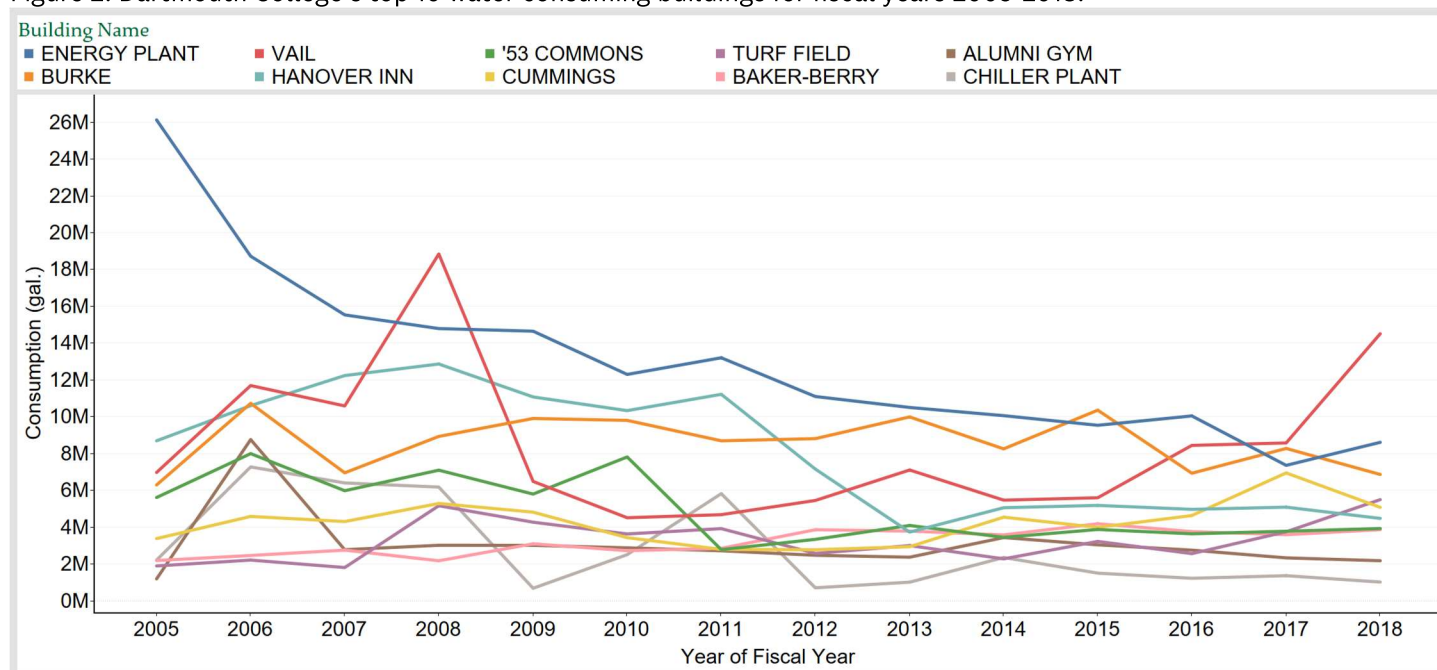
<sup>1</sup> Statistical relationships are traditionally considered 'significant', i.e., meaningful, when the p-value (p) is less than 0.05.

## Building Water Consumption

### Building Water Consumption Summary

The CEP, Burke Chemistry Laboratory (Burke), Hanover Inn, Vail Medical Building (Vail), and Cummings Hall have been the College's top five median water consuming buildings since 2005. In 2018, Scully-Fahey Field edged out the Hanover Inn for a spot on this list of top water consumers. Vail was the College's largest consumer of water in 2018; it consumed 14.5M gal. of water, or 11% of the College's total annual consumption. The CEP was the College's second largest consumer of water; it consumed 8.6M gal., or 6% of the College's total consumption in 2018. Dartmouth's top five water consuming buildings consumed 30% of the College's water (40.6M gal. in 2018) and the top ten consumed 42% (56.0M gal. in 2018). The average consumption of these top ten buildings is 5.9M gal. per year, far exceeding the average of 0.5Mgal. per year for all remaining buildings.

Figure 2. Dartmouth College's top 10 water consuming buildings for fiscal years 2005-2018.



### Building Water Consumption Rankings

The CEP, Vail, and Burke have traded off being the three largest consumers of water since 2005. The CEP was the largest consumer of water, except when Vail Medical Building consumed more water in 2008 than the CEP between 2005 and 2014. Since 2014, the CEP, Vail, and Burke have traded first, second, and third place as the largest water consumers; in 2015, Burke was the largest, in 2016, the CEP was the largest, and in 2017 and 2018 Vail was the largest water consumer.

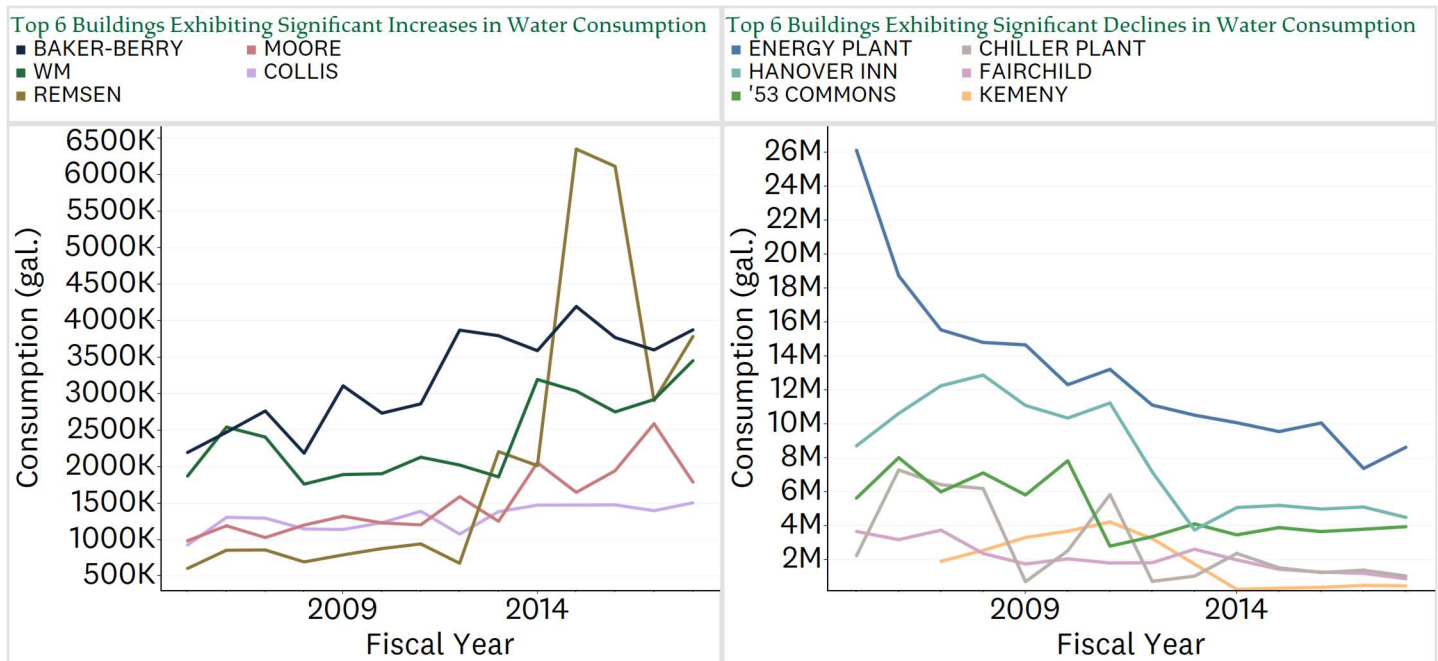
### Building Water Consumption Trends

Of the top 30 water consuming buildings, five buildings exhibited significantly ( $p < 0.05$ ) increasing water consumption (Fig. 3 left panel) and six exhibited significantly ( $p < 0.05$ ) declining water consumption (Fig. 3 right panel) between 2005 and 2018. The largest increases in water consumption occurred in buildings that are not in the top ten water consumers (Fig. 2), but that use above the average amount of water for buildings at Dartmouth. Of the five buildings with the greatest increases, two are science buildings, Remsen and Moore Halls, one is the College's main library complex, Baker-Berry, one is the main undergraduate student center, Collis, and one is the Tuck Schools' mixed academic and graduate housing complex, Whittemore-Murdough. Remsen has exhibited the largest increase in water consumption; in 2005 Remsen consumed 0.6M gal,

whereas in 2018 it consumed 3.8M gal., a difference of 3.2M gal. or a 527% increase. Baker-Berry has been the largest water consumer that is exhibiting a growth in water consumption; Baker-Berry's water consumption was significantly ( $p < 0.0001$ ) increased from 2.2M gal. in 2005 to 3.9M gal. in 2018, an increase of 1.7M gal. or 77%. Moore, Whittemore-Murdough, and Collis have grown by 80%, 79%, and 67% from 2005 to 2018 respectively.

The largest declines in water consumption include four of the College's top 10 water consuming buildings, the CEP, Hanover Inn, '53 Commons, and the Chiller Plant plus two other buildings, the Fairchild Sciences Complex and Kemeny Hall. The CEP's water consumption has declined steadily since 2005 when it consumed over three times as much water as it did in 2018 (26.1M gal vs 8.6M gal.). The Hanover Inn's renovations in 2011-2012 have had a large, positive impact on its water consumption. Once the second or third largest consumer of water at the College, it is now the sixth largest consumer (Fig. 3). Prior to the renovation, its average use was 10.5M gal. per year. Following the renovation, its use has declined to 4.8M gal. per year between 2013-18, a greater than 50% reduction in consumption. The Class of 1953 Commons renovation in 2010-11 had a large, positive impact on its water consumption. 1953 Commons used an average of 6.7M gal from 2005-10. Following renovation, it has consumed 3.6M gal. on average between 2011-18 (Fig. 3).

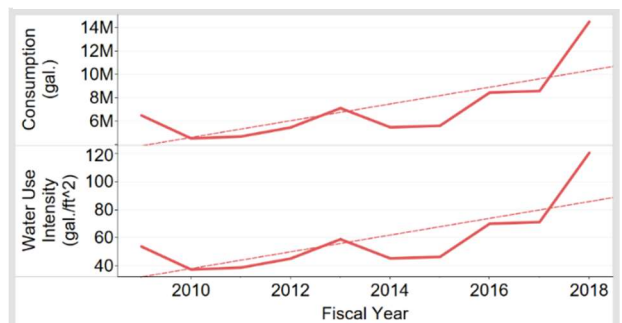
Figure 3. Dartmouth's five largest increasing and decreasing water consumers from fiscal year 2005 to 2018.



### Vail's Water Consumption and Use Intensity

In 2017 and 2018, Vail consumed the most water of any building at Dartmouth, but because of a spike in water consumption in 2008, a major decline in 2009, and then steadily rising water consumption rates until 2018 (Fig. 2), Vail's water consumption and use intensity do not exhibit a statistically significant relationship when including its 2005-2008 data. However, since 2009, Vail's water consumption and use intensity have increased significantly ( $p < 0.02$ , Fig. 4).

Figure 4. Vail's water consumption and use intensity between 2009-2018.





## Building Water Use Intensity

### Building Water Use Intensity Summary

The Fuller Boathouse, Shabazz Center, Jewel of India, the East Wheelock Cluster, and Burke have had the five largest water use intensities on average since 2005. Note: The Central Energy Plant and Chiller Plant water use intensities are not included in this discussion because their water consumption is associated with servicing many buildings on campus. Private residences owned by the Real Estate Office are also excluded from this discussion.

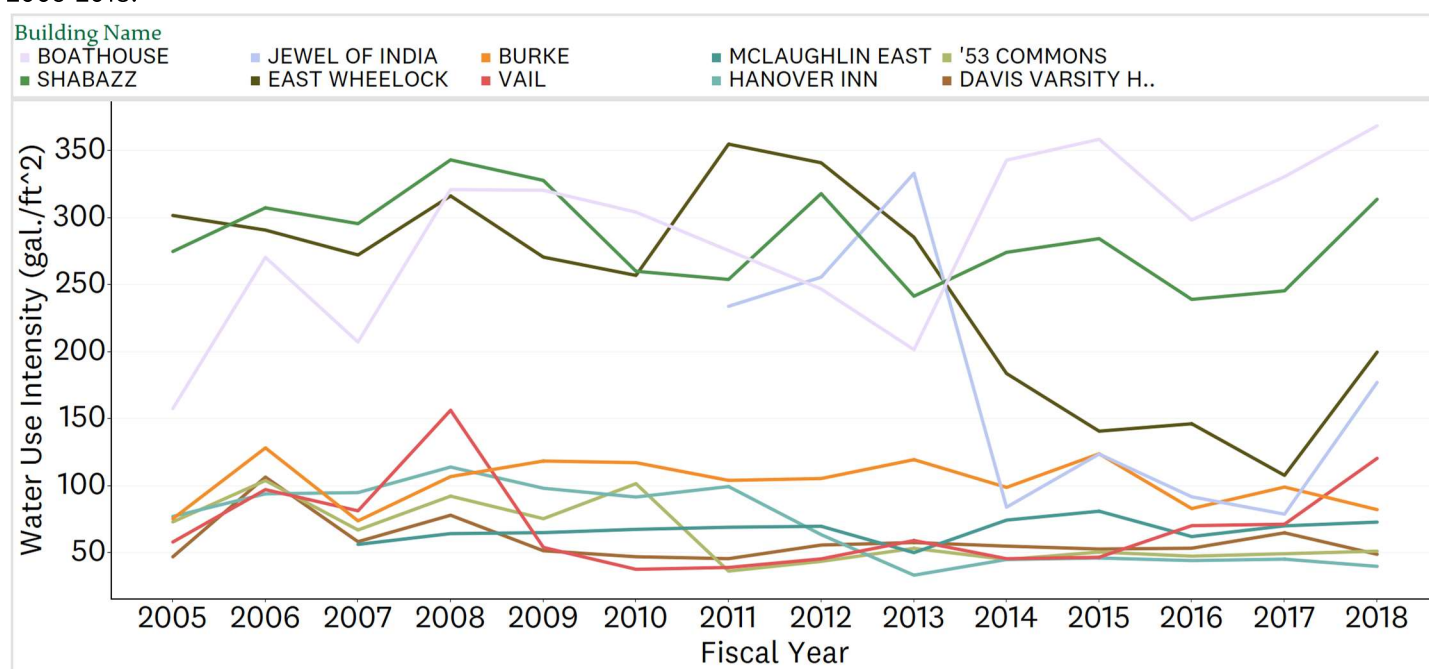
### Building Water Use Intensity Trends

The Fuller Boathouse is the only building in the top ten that has exhibited a significant ( $p < 0.02$ ) increase in its water use intensity between 2005 and 2018. The Fuller Boathouse's has had an average water use intensity of 286 gal./ft<sup>2</sup> between 2005-2018. Shabazz's water use intensity has not changed significantly between 2005 and 2018, but it also has a very high average water use intensity of 284 gal./ft<sup>2</sup> between 2005-2018.

Only three other Dartmouth buildings, Jewel of India, the East Wheelock Cluster, and Burke, have had average water use intensities greater than 100 gal./ft<sup>2</sup> between 2005 and 2018. The East Wheelock Cluster's water use intensity significantly ( $p < 0.001$ ) declined between 2005 and 2018 from the top water use intensity building in 2011 to the third largest in 2018. The East Wheelock Cluster used an average of 258 gal./ft<sup>2</sup> from 2005-2013 and 63 gal./ft<sup>2</sup> from 2014-18<sup>2</sup>. Jewel of India's water use intensity has declined steeply from an average of 274 gal./ft<sup>2</sup> in 2011-2013 to an average of 111 gal./ft<sup>2</sup> in 2014-2018; since 2011, its average water use intensity has been 172 gal./ft<sup>2</sup>.

In 2018, only the Boathouse and Shabazz use greater than 300 gal./ft<sup>2</sup>, while the next greatest building, the East Wheelock Cluster, uses 200 gal./ft<sup>2</sup>. Jewel of India and Vail both had water use intensities in the 100-200 gal./ft<sup>2</sup> range, while the other five buildings in the top ten had water use intensities less than 100 gal./ft<sup>2</sup>.

Figure 5. Dartmouth's top 10 water use intensity by building types excluding REO rental housing units for fiscal years 2005-2018.



<sup>2</sup> 2017 data are excluded from this calculation due to a fire that closed the building during this period.

## Water Consumption by Building Types

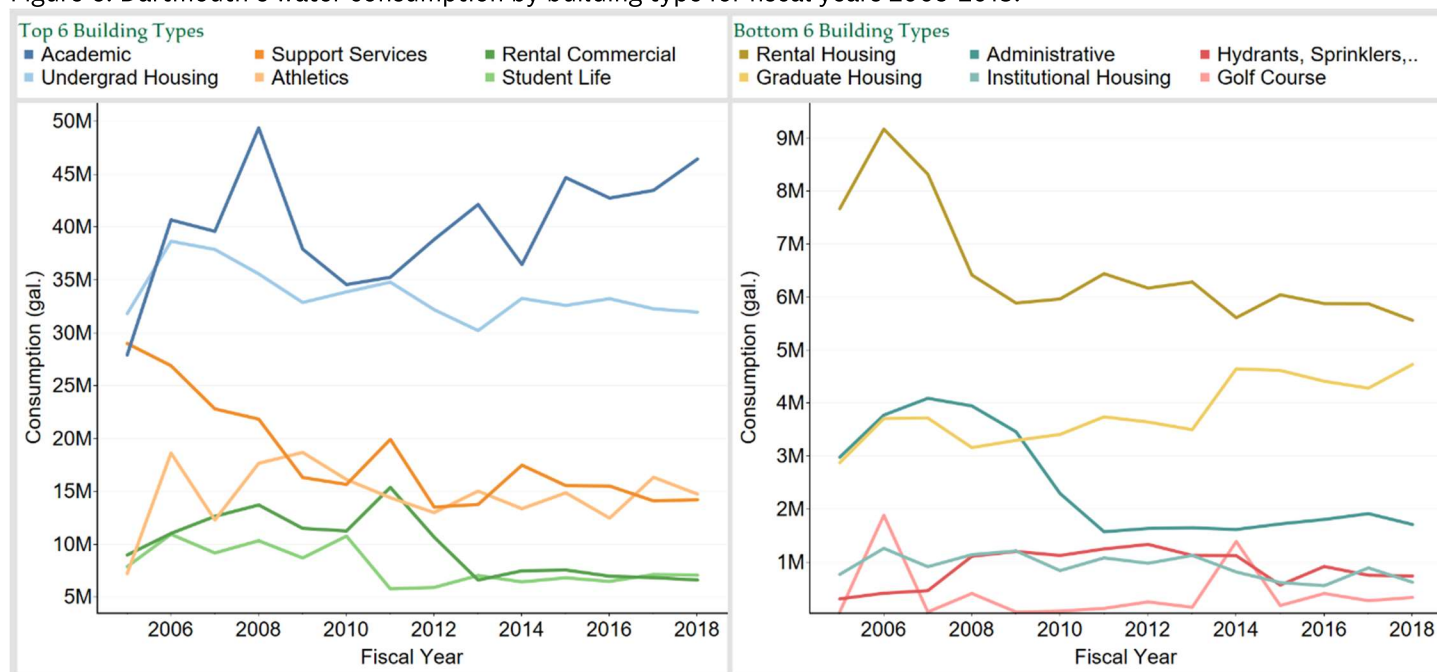
The College has distinct types of buildings or locations where water is consumed. For our water data analyses, we broke the College's buildings into 12 types: Academic, Administrative, Athletics, Golf Course, Graduate Housing, Institutional Housing, Rental Housing, Rental Commercial, Student Life, Support Services, Undergraduate Housing and Hydrants, Sprinklers, and Tanks.

Academic buildings consumed the most water in 2018, 46.4M gallons or 34% of the College's total consumption. The top two water consuming building types, academic and undergraduate housing, consumed 58% of the College's annual water consumption in 2018.

## Key Trends in Water Consumption by Building Types

- Graduate Housing (p<0.001) and Academic (p=0.08) buildings have exhibited increasing water consumption between 2005 and 2018 (Fig. 6).
- Undergraduate Housing, Support Services, Rental Commercial, Student Life, Rental Housing, Administrative, and Institutional Housing have had significant (p<0.05) water consumption declines between 2005 and 2018 (Fig. 6).
- Athletics buildings have not exhibited increasing or decreasing water use between 2005 and 2018 but have consistently used a lot of water. Athletic buildings have used an average of 14.6M gal. per year between 2005 and 2018; only three building types have had average greater water consumption during this period, Academic (avg. = 40.0M gal.), Undergraduate Housing (avg. = 33.7M gal.), and Support Services (avg. = 18.3M gal.) (Fig. 6).

Figure 6. Dartmouth's water consumption by building type for fiscal years 2005-2018.

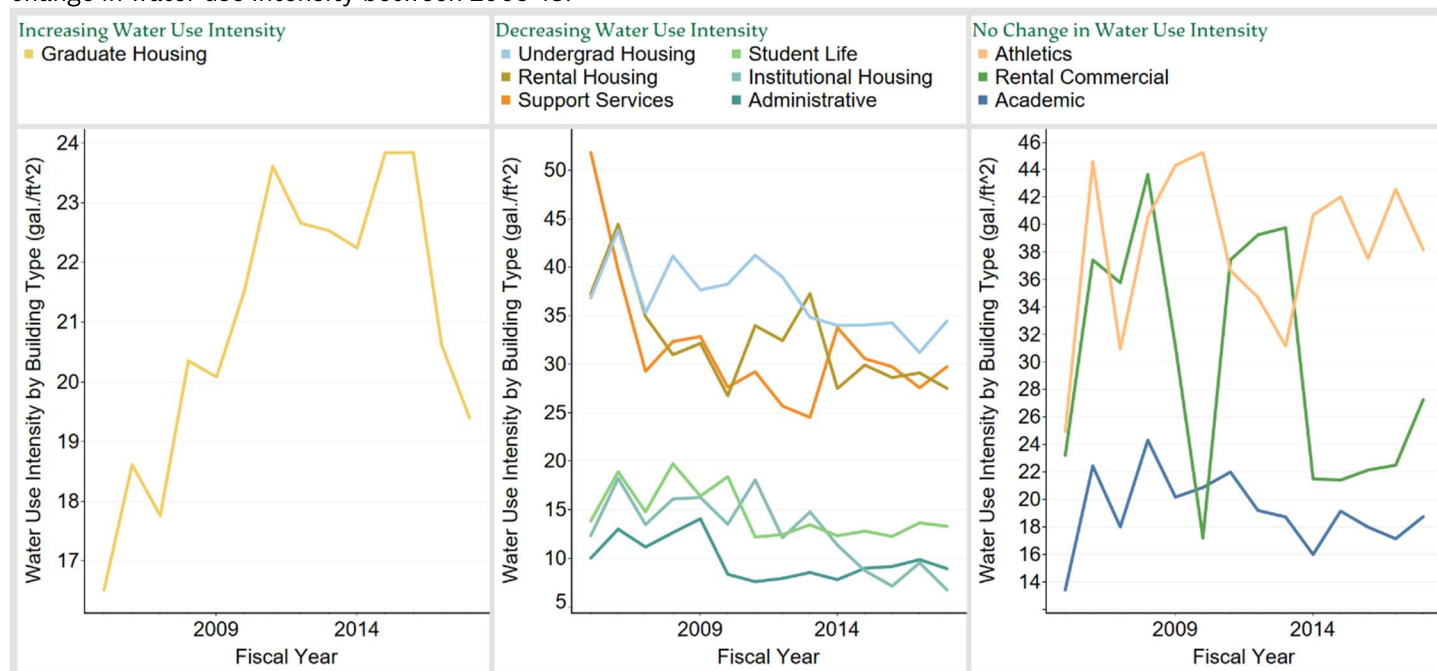


## Key Trends in Water Use Intensity by Building Types

- Graduate Housing buildings are the only building type for which their water use intensity is increasing between 2005 and 2018 (Fig. 7.)
- Undergraduate housing, rental housing, support services, student life, institutional housing, and administrative building types exhibited significant (p<0.05) declines in water use intensity between 2005 and 2018 (Fig. 7).
- Athletics, Rental Commercial, and Academic buildings have not had significant changes in their water use intensities between 2005 and 2018. Note: two building types are excluded from our assessment of water

use intensity, hydrants, sprinklers, and tanks and the golf course because we did not allocate square footage to them (Fig. 7.).

Figure 7. Dartmouth's building types with significantly ( $p < 0.05$ ) increasing and decreasing water use intensity and no change in water use intensity between 2005-18.



## Water Reporting History

This report on water use patterns at Dartmouth, including both the main campus and Real Estate Office owned or managed properties, is the first complete evaluation of the College's water footprint.

This report completes the Our Green Future report goal of measuring and tracking Dartmouth's water consumption and use patterns and developing an annual water report that makes our use visible and identifies opportunities for improvement.

The consumption and use trends identified in this report will allow us to identify opportunities for improvement that reduce the financial, environmental, and social impacts of water consumption. Next steps include setting appropriate goals and timelines for reducing water consumption and improving water efficiency on campus.



## Appendices

### Our Green Future: Water

In the Northeast, the supply of clean water is often not considered a major sustainability concern because it is relatively abundant. However, most forecasts of the impacts of climate change over time include variability in both average annual rainfall and in how water systems function. These will no doubt have impact here in Hanover and it is sensible to manage our water system with long-term sustainability and resiliency in mind.

*Water Principle 1:* Measure and track Dartmouth's water consumption and use patterns, assessing opportunities for increasing the efficiency of water consumption and decreasing water waste, and the extent to which these are the best use of resources.

*Goal:* By the end of calendar year 2018, develop an annual water report that shows consumption and use patterns and identifies opportunities for improvement.

*Commitments:* By the end of calendar year 2019, assess the impacts (financial, sustainability related, social) of goals for reducing water use (including reuse) and improving water efficiency. Determine if goals on water efficiency make sense for Dartmouth.

### Data Manipulation Notes

- The Town of Hanover reads most meters once each fiscal quarter, e.g., first quarter (July-Sept.) reads usually take place late in September, but sometimes meters are missed, fail to transmit their data, or break. In cases where data are missing, incorrect, etc., a meter's water consumption is either estimated for the quarter or the consumption compounds until the meter is read again, fixed, or replaced. In cases where the data compounded for multiple quarters, we divided the consumption by the number of months and allocated an equal fraction to each of the missing quarters and the quarter with the read.
- We created multiple aliases for different building clusters to accurately describe the buildings served by water meters.
  - We created an East Wheelock Cluster alias to represent two meters, Andres and Morton Hall's meters, which service all the dorms in the East Wheelock Cluster dorms including Zimmerman and McCulloch that do not have their own unique water meters.
  - We created a North Park House alias to represent water consumed by three buildings, Ripley, Woodward, and Smith Halls, but that is serviced by only one meter, known to the Town as Ripley.
  - We created a Central Energy Plant alias to represent all the water consumed by the CEP, which according to our data, is fed by at least four different meters. An additional meter may have been added and we are still investigating.

### Building Data

- 208 of those meters are owned/managed by the College's Real Estate Office
- 3 meters correspond to the Thayer School of Engineering
  - All three of Thayer's buildings are classified as academic buildings
- 11 Correspond to Tuck School of Business; 6 of those 11 were for temporary housing in 2005-2007, while the remaining 5 meters are for extant buildings
  - Of the five extant buildings, one is academic, two are administrative, one is graduate housing, and one is student life.
- 106 meters belong to the College's General Plant, i.e. the central facilities of the College such as its Central Energy Plant, chilled-water generation facilities, and academic buildings

such as Dartmouth Hall, athletic facilities such as Thompson Arena, and student life buildings such as Collis.

- 29 Academic buildings
  - 11 administrative buildings
  - 20 athletics buildings
  - 8 golf course buildings
  - 6 hydrant, sprinklers, and tanks
  - 11 Institutional Housing
  - 8 Student Life
  - 13 Support Services
- 5 meters belong to the Geisel School of Medicine; three of the Geisel Buildings in our records are extant, Remsen, Vail, and Kellogg.
  - 3 academic buildings
- 59 meters correspond to the Dean of the College, i.e., the residential buildings of the College; 57 of these buildings or meters are extant.
  - 3 institutional housing; 2 extant, 1 extinct (18 South St)
  - 1 student life
- 55 undergraduate housing; 53 extant, 2 extinct (Hinman and Brewster)