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ELECTRONIC REGISTRATION SYSTEMS

FOR COOLING TOWERS

Improving
PUBLIC HEALTH AND
SUSTAINABILITY OUTCOMES

A report for USDN by:

NSF

GroveWare TECHNOLOGIES

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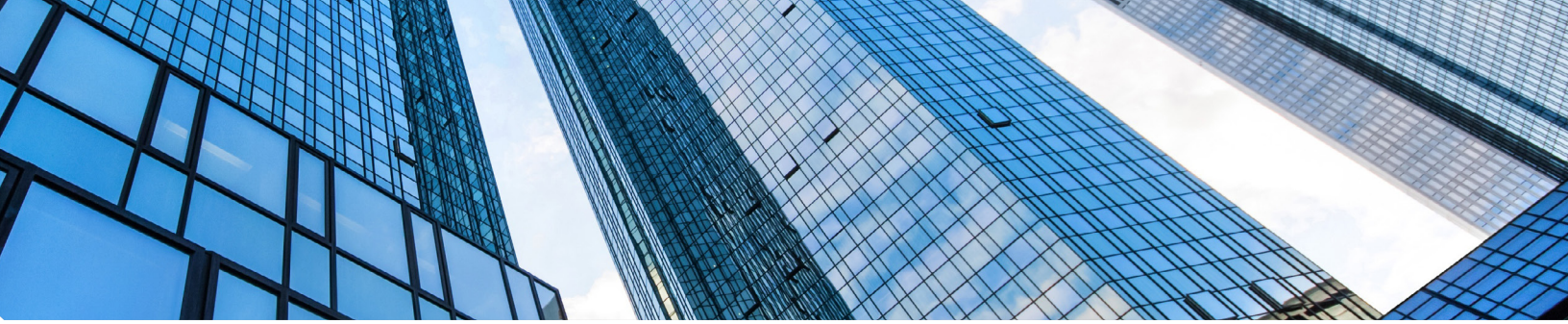

Participant Cities

Aurora, CO	Observing City
Austin, TX	Observing City
Boston, MA	Observing City
Calgary, AB	Observing City
Public Services and Procurement Canada	External Participant
Chicago, IL	Observing City
Edmonton, AB	Primary City
Groveware	External Participant
Guelph, ON	Observing City
Hamilton, ON	Non-USDN Participant
Los Angeles, CA	Observing City
Los Angeles Better Buildings Challenge	External Participant
Montreal, QC	Primary City
Nashville, TN	Observing City
New Orleans, LA	Observing City
New York, City of	Observing City
New York, State of	Non-USDN Participant
NSF Health Sciences	External Participant
Philadelphia, PA	Primary City
Richmond, BC	Observing City
San Antonio, TX	Observing City
Southern Nevada Health District	Non-USDN Participant
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Surrey, BC	Observing City
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1. DOCUMENT PURPOSE

This document is meant to support jurisdictions as they engage in the process of setting up a web-based cooling tower registration system. Web-based registries allow a wide range of stakeholders – jurisdictions, building owners, environmental consultants, water treatment firms – to input and assess critical information that provides transparency as to whether public health and sustainability goals are being met.

The document is designed to provide a standardized yet flexible template that jurisdictions can adopt to ultimately improve health outcomes, address inequity and increase water and energy efficiency.

The report highlights:

- the benefits of registries in terms of public health and sustainability gains.
- the versatility of web-based registry systems, and illustrates various possible models, based on the types of data included and the goals they are designed to measure.
- the importance of making the registry mandatory in order to obtain desired results.
- the functional and performance requirements that should guide any jurisdiction when creating a standardized Cooling Tower Registration System or CTRS.

Section 2, 3 and Appendix A will be relevant to professionals in the public health and sustainability fields interested in learning more about cooling towers and concerned with how to address their impacts on the populations they serve. Section 4 is targeted specifically to IT professionals designing the registry systems.

2. BACKGROUND

There are over 2 million cooling tower systems in North America, and they are found commonly as part of commercial, industrial, residential, health care and institutional buildings. Cooling towers are a critical component of many cooling systems and are the point where heat extracted from a building is dissipated to the atmosphere through the evaporative process. Cooling towers are designed to create as much evaporation as possible by maximizing the surface area of the water as it flows over and down through the tower structure. As the air passes through the water, it cools the air and warms the water, causing some of the water to evaporate. The heat and evaporated water flow out the top of the tower in the form of a fine cloud-like mist.

The heat exchange between water and hot air creates an ideal environment for the growth of *Legionella*, the bacteria responsible for a severe form of pneumonia known as Legionnaires' disease that can lead to respiratory failure and death. The bacteria travel out of the system in the water droplets that are part of the evaporative mist. Proper maintenance of the cooling tower is essential to prevent the bacteria from colonizing the tower.[1] A diagram of the heat exchange process in a cooling tower appears in Figure 1.

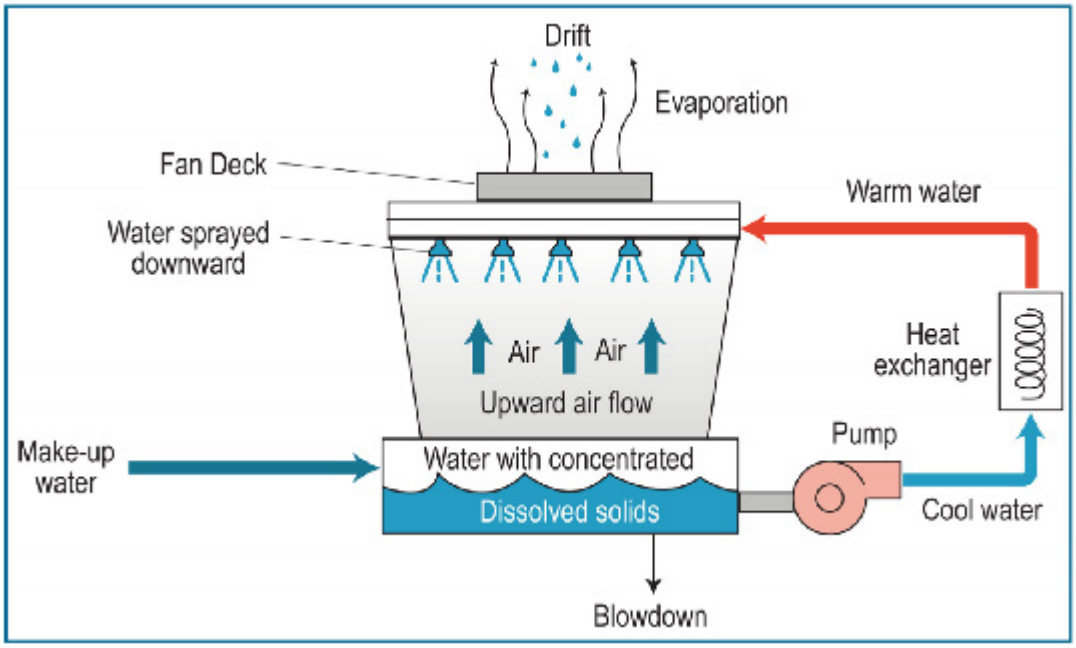


Figure 1.
Illustration of Water Flow Across a Cooling Tower. *Source: US Department of Energy Federal Energy Management Program "Cooling Towers: Understanding Key Components of Cooling Towers and How to Improve Water Efficiency" EERE Information Center, February 2011.*

https://www1.eere.energy.gov/femp/pdfs/waterfs_coolingtowers.pdf

Despite these systems being commonly associated with disease and death when not properly managed, there are only a handful of jurisdictions that have established any expectations for a building owner to manage the risks associated with cooling tower systems. Other common engineered building systems such as elevators, escalators, boilers, and fire alarm systems typically require annual operating permits and inspections. In contrast, most North American cities do not know where the cooling towers are, and are forced to rely on imprecise methodologies during public health emergencies to identify their location and evaluate if they are properly maintained and not causing disease. In contrast, we do not accept elevator malfunctions plunging people to their deaths, and there are safety codes and standards in place to prevent this from happening. Yet cooling towers, despite being more common than elevators,[2] continue to kill and injure people through exposure to *Legionella* with continued tolerance of widely divergent maintenance practices by building owners.

Given the lack of standardized requirements, cooling tower maintenance practices are often based on highly idiosyncratic rationale such as a brand reputation and liability risk. Generally, proactive and effective management of risk is limited to a small segment of Class A buildings and national brands that have internal water management requirements. Unsurprisingly, then, there is a systematic difference in the disease burden for *Legionella* based on poverty and racial and ethnic group, because building owners in areas with high poverty tend to be less diligent with building maintenance.[3]

This document does not purport to solve all of the public health, equity and sustainability issues associated with cooling towers, such as developing common regulatory requirements for improving sustainability and public health outcomes, disease surveillance strategies, response protocols to increases in cases, public health risk messaging, or outbreak investigation protocols. Rather, the document presents pragmatic and realistic first steps that can be implemented by cities and other jurisdictions quickly and with little operational burden: the creation of a cooling tower registry that captures key factors influencing sustainability and public health outcomes.

The critical importance of cooling tower registrations is widely accepted internationally and is a cornerstone recommendation of the National Academy of Sciences, Medicine and Engineering's August 2019 report addressing the rapid increase in Legionnaires' disease: "Regulations and guidelines requiring the registration of cooling towers provide a demonstrable public health benefit with minimal regulatory burden to building owners and managers. Cooling tower registries enable a rapid public health response to community clusters of legionellosis cases, including timely remediation of possible sources of infection, and they can also be used to assess the contribution of cooling towers to overall disease incidence."[4]

The critical importance of cooling tower registrations is widely accepted internationally and is a cornerstone recommendation of the National Academy of Sciences, Medicine and Engineering's August 2019 report addressing the rapid increase in Legionnaires' disease.

Cooling towers are the most commonly confirmed source of the bacterium that causes Legionnaires' disease outbreaks and are responsible for the majority of outbreak deaths.[5] Though the incidence of the disease is widely underreported, estimates suggest as many as 70,000 people may suffer from Legionnaires' disease each year in the United States alone[6] and 1 out of 10 of those will die.[7] The reported number of cases represents an eight-fold increase since 2000.[8] *Legionella* infections impact vulnerable populations most severely. The elderly and immunocompromised are particularly susceptible;[9] its impact on children requires further study.[10] Given the public health costs of this deadly yet underestimated disease, jurisdictions should take cost-effective, proactive measures that promote prevention.

Cooling tower registries are widely considered one of the best practices in preventing and improving the response to legionellosis outbreaks.[11] Registries, by seeking to identify all cooling towers within a jurisdiction, have proven to be a powerful tool in ensuring the implementation of proper maintenance plans that help prevent diseases such as legionellosis. Furthermore, in the unfortunate case of a disease outbreak, the cooling tower registries allow authorities to take swift action to identify likely sources and carry out remediation.

Cooling tower registries can also be a crucial tool in helping jurisdictions measure key performance indicators related to sustainability. Cooling towers are a significant source of water demand for a building, representing 20-50% of total water usage.[12] Poor management practices result in millions of wasted gallons of water per year. A moderately well managed 5,000-ton cooling tower that needs to operate 50% of the time can use 50 million gallons of water annually. Buildings that have poor energy conservation practices increase the "load" on the cooling tower systems, requiring these systems to operate more frequently and increasing water, energy, and chemical addition demands. In Los Angeles, it has been estimated that poor management practices of cooling towers waste over two billion gallons of water per year.[13] Registries can be used to evaluate the effectiveness maintenance plans and thus identify areas for improvement in a building's water and energy efficiency.

The benefits of establishing cooling tower registries are numerous.

- **Registries remove a key barrier to action by building localized infrastructure knowledge.** While registries are critical in identifying possible foci of infection during *Legionella* outbreaks, they can be used for outreach in a wide range of situations. For example, in case of water main or other disruptions to the water supply, water utilities can use unique building identifier information to communicate and notify affected building owners of potentially elevated risks.[14]

- **Registries provide data that can be used to assess how cooling tower management practices impact public health, sustainability and equity concerns.** Jurisdictions that have created standardized cooling tower registration systems have been able to use the data to become significantly more efficient when evaluating cooling tower management plans. They have also benefited from being able to estimate sustainability gains and reductions in public health risk achieved by improved management plans.

- **Registries can help streamline administrative processes already in place.** Since the information collected by the cooling tower registry is stored in a centralized database, it is readily shareable between organizations with overlapping regulatory purviews allowing jurisdictions to experience efficiency and productivity gains. For example, a cooling tower registry can be used to estimate the impact of technical assistance provided to improve water efficiency. Based on cooling tower characteristics, a water utility can target its outreach and marketing efforts for water efficiency programs. If the water utility has a water sewer credit/ evaporation credit program for cooling towers, the registry can streamline the documentation needed to issue credits and document whether a cooling tower is meeting required levels of efficiency.

- **Registries offer benefits of increased monitoring of water usage and discharge.** Utilities that establish and/or support cooling tower registries can increase their ability to monitor key indicators of water safety and environmental compliance, including documenting whether required backflow prevention devices are in place, the quality of the water discharged to sewer, and even rain and storm water management practices.

- **Registries can also support the monitoring of energy efficiency.** More energy efficient buildings will have less need to expel excess heat. Data from the registry could be used to determine the cooling tower load, and therefore assess whether the building is meeting sustainability goals. Once in place, the cooling tower registry also can be leveraged to capture other building level data critical to public health and sustainability goals.

Examples of cities that require owners to register cooling towers are New York City; Austin, Texas; Hamilton, Canada; and Vancouver, Canada. State and Province-wide registries exist in New York, Quebec and Victoria (Australia). At the time of writing, Florida is proposing a state-wide registry. National registries exist in several European countries such as the United Kingdom, France, and the Netherlands, but also in Hong Kong, and Singapore.[15]

There are jurisdictions that have made registration voluntary. However, the data suggests that voluntary registries have very low participation from building owners and therefore are not successful in creating reliable databases of cooling towers. Because of this, voluntary registries are unlikely to have significant impact in terms of the public health and sustainability goals we outline in this document. Comparing the experiences of San Antonio, Texas and Austin, Texas, provides a good illustration of our point. Austin has taken a proactive approach in ensuring that building owners comply with its cooling tower registration regulations, and successfully registered hundreds of its cooling towers. In contrast, San Antonio has not actively enforced compliance and only has a handful of cooling towers on its records. Their experience strongly indicates that establishing a registry is not sufficient; jurisdictions should go through the necessary channels to make cooling tower registration mandatory and enforceable.

3. WEB-BASED COOLING TOWER REGISTRATION SYSTEMS: A MODULAR APPROACH

Cooling Tower Registry Systems (CTRS) are pragmatic and realistic first steps to capture key factors influencing sustainability and public health outcomes. Jurisdictions can implement these registries quickly and with little operational burden. Furthermore, these registries can be easily adapted to meet a wide range of different requirements, giving jurisdictions the necessary flexibility to decide the extent of data collection and monitoring they require. At the most basic level, a registry can consist of just a few basic parameters collected on a web-based form. Jurisdictions can build increasing complexity to the system to meet their goals as needed.

However, it is important to note that in order for the registry to properly function as a tool that improves health outcomes and increases water and energy efficiency, there are some minimum data points that must be collected. To effectively initiate and then scale the cooling tower registry, a jurisdiction must:

- *Build a registry around the relationship between a unique building identifier established by the jurisdiction and the cooling tower(s) associated with this building/property.* From this initial relational association, the jurisdiction can begin to organize the other public health and sustainability data points it wishes to collect.
- *Capture the key performance indicators that drive successful management of these systems.* The range of information collected will be determined by the jurisdiction based on their authorities and policy goals.
- A jurisdiction looking to *improve disease surveillance and response* might choose to create a simple CTRS with limited data requirements, such as building location information and basic design characteristics of the cooling tower systems at the building. An example of the type of information collected can be found in **Form A** [A] of the Hamilton, Canada registry.
- A jurisdiction looking to *prevent disease and improve the management of risk* would need to create a more robust CTRS that collects additional data on routine maintenance practices, validation sampling results for bacterial growth and *Legionella*, and information on the water treatment program. This could also include submission of independent inspection reports documenting the implementation of the water management program and necessary corrective actions to elevation in risk, similar to what jurisdictions require for other life and safety systems such as fire suppression, elevators, boilers, and gas line connections. Such a system has been adopted by **New York State** [B] and **New York City** [C], and is being proposed in the State of Florida.
- A jurisdiction interested in *identifying key sustainability indicators* such as water reuse, conservation and resiliency opportunities may focus on the following indicators: efficiency of the cooling towers, expressed as cycles of concentration; make-up water source; presence of water meters and water usage data; location; cooling capacity; total recirculating water; water basin size; as well as automated water management programs to adjust chemical feed cycles that improve water efficiency. This type of system has been adopted by **Austin, Texas** [D], and is being proposed in the State of Florida. Additional information on sustainability indicators is provided in Appendix A.

As the data collected during and after the registration of the cooling tower system becomes more complex, it is critical to have a CTRS that is capable of efficiently managing multiple user roles input. The table here provides examples of different types of users that might interact with the system, and the different tasks they might perform.

Regulations and guidelines requiring the registration of cooling towers provide a demonstrable public health benefit with minimal regulatory burden to building owners and managers. Cooling tower registries enable a rapid public health response to community clusters of legionellosis cases, including timely remediation of possible sources of infection, and they can also be used to assess the contribution of cooling towers to overall disease incidence.

USER	EXAMPLES OF DATA MANAGEMENT RESPONSIBILITY	DATA ACCESS
Jurisdiction	Will vary in different jurisdictions based on the complexity of the data tracking system. > Link cooling tower data to other building data managed by jurisdiction > Associate unique building ID with cooling tower based on standardized address input by building owner > Ensure exact match between jurisdiction and owner records; building in automatic validation by system is most effective	Access to all data
Health Departments	Associate data collected in the course of outbreak investigations and independent inspections to cooling towers	Access to all data
Public Utilities and Sustainability Officials	Associate water and energy usage data of building and, if available, cooling tower	Access to all data
Building Owners/ Representatives	Input cooling tower registration information > Building Address > Cooling tower type, make and model, cooling capacity, circulating volume and storage capacity > Routine updates of such as maintenance logs, sampling results and data points determined by jurisdictions	Access to information regarding their buildings and update information for accuracy
Public	None	To be determined by the jurisdiction. Recommended: access to cooling tower locations and compliance with existing regulations. An example is the **New York State public portal** [E].

[A] **Form A:** https://tinyurl.com/qwu2r2n
[B] **New York State:** https://tinyurl.com/t3z48zu
[C] **New York City:** https://tinyurl.com/yx5lgxgj
[D] **Austin, Texas:** https://tinyurl.com/uwvrqsx
[E] **New York State public portal :** https://tinyurl.com/ul6h94n

In summary, the previous sections have outlined the impacts of cooling towers on public health and sustainability. We have emphasized the need for jurisdictions to embrace strategies that allow them to better monitor cooling tower maintenance practices and increase enforcement of cooling tower maintenance regulations. We argue that cooling tower registries are one of the most effective mechanisms to achieve these goals and can be indispensable when implementing other practices such as disease surveillance strategies, response protocols to increases in cases, public health risk messaging, or outbreak investigation protocols. Section 4 provides IT professionals with a guide for how to build an online cooling tower registry system (CTRS) portal.

4. COOLING TOWER PORTAL APPLICATION ARCHITECTURE

This section is intended to be a guide for IT professionals. It describes how to create a Cooling Tower Registry Portal (CTRP). The Portal is the public interface that allows users to access the system. This chapter is organized to support IT professionals design a comprehensive web-based registry and how to organize how data is entered into the CRTP. The CTRP presented in this document provides the technical details needed to create an online, web-based interface to facilitate the input and ongoing collection of a broad range of data points, how data is submitted, user roles, and provides examples of the look and feel of a CTRP.

The design of the public interface or portal becomes crucial to the success of the system. The Portal stores all relevant information to a cooling tower system, starting with the building it is located in (premise), the Cooling Tower System(s) ("System") that exist within the building and the Cooling Tower Equipment ("Equipment") that is used within the System. The information collected includes contact information (building owner, property management and water treatment companies) as well as technical information related to the Cooling Tower itself (cooling capacity, total water circulation, treatment methods, seasonality, estimated efficiency, water quality parameters, maintenance practices, commission dates, etc.). The information collected provides the jurisdiction the power to manage public health and sustainability issues related to Cooling Towers.

In the tables that follow readers will find a high-level overview of the system organized by application layer. The application can be broken down into three layers: presentation, business

COMPONENT	DESCRIPTION
PRESENTATION LAYER	
Graphical User Interface (GUI) and Navigation	This component is the implementation of the proposed graphical user interface. The GUI and navigation is designed to be accessed with a web browser to perform business tasks. This is made up of the login page, horizontal tabs, vertical navigation components and the main work area where information is entered, results are displayed and where forms are viewed, edited and submitted.
Search Premise	This visual component gives the user the ability to search for a premise by choosing search criteria and a search keyword. The search result displays a matching list of premises. From the result list users can link to the inspection forms to enter data corresponding to an inspection on that premise. As well, they can link to the Premise Maintenance Form to add or edit information about premises.
View Submissions	This visual component gives the user the ability to view and edit forms entered previously into the system. There are add-on capabilities for additional forms in the future.
Knowledge Centre	This component provides access to various documents that provide information and support the Cooling Tower Registration process.
Tools/Profiles	This visual component displays a list of links to specific functionality.

COMPONENT	DESCRIPTION
BUSINESS LAYER	
Search Engine	This service is responsible for accepting search keywords and filters. The search engine uses the keywords to scan the database index for a match and is also responsible for maintaining indexes of objects. Initially, the application will handle searches for premises, but functionality can be extended to allow search for other objects.
Authentication and Authorization	This component is used by the Registration Portal to manage user authentication and authorization based on a database of usernames and passwords maintained within the Registration Portal.
Search Engine	This service is responsible for accepting search keywords and filters. The search engine uses the keywords to scan the database index for a match and is also responsible for maintaining indexes of objects. Initially, the application will handle searches for premises, but functionality can be extended to allow search for other objects.
Authentication and Authorization	This component is used by the Registration Portal to manage user authentication and authorization based on a database of usernames and passwords maintained within the Registration Portal.

COMPONENT	DESCRIPTION
DATA LAYER	
Form Definitions	This is a collection of form data elements, events and format of a particular form stored in Relational database.
Form Instances	A form instance is created when data for a new form is entered into the system as part of the application workflow. It contains data entered by a user or data loaded as part of an integration interface. Each form instance should also have chronological versions that can be used for auditing and tracking changes.
Users & Groups	User and groups are created to manage security for the application. A user represents a single individual with access to the application and is identified based on the authentication credentials. Groups is a way of arranging users within functional or structural categories to simplify the process of assigning permissions.
Permissions	Permissions are access levels (i.e. read, edit, delete, etc.) associated with one application object (i.e. a form) and a user or a group.

The following section will provide more detailed information and will focus primarily on the presentation layer components that make up the user interface design.

User Interface Design

The Portal is web-based and all interactions with the system are accomplished through an Internet browser. The graphical user interface is provided through the system application layer that should provide a standard framework to setup forms and navigational elements. The sections that follow describe the user workspace, the overall application workflow and the individual forms and screens.

4.1 THE USER WORKSPACE

The Portal user interface should provide the following workspace from which all application functionality is handled: Management of Buildings' Equipment and System Registration, as well as Compliance monitoring activities and Reporting. The CTRS Portal allows data to be presented to a range of users – including jurisdictions, building owners and the general public – to track specific work tasks and assignments for jurisdiction, building owner, vendors, and/or independent inspectors. It also allows standardized reports and dashboards to show whether individual cooling towers are meeting key performance indicators in relation to sustainability or public health, as well as overall trends for all cooling towers in the jurisdiction. Figures 2 a, b, and c offer examples of how the portal interface might look.

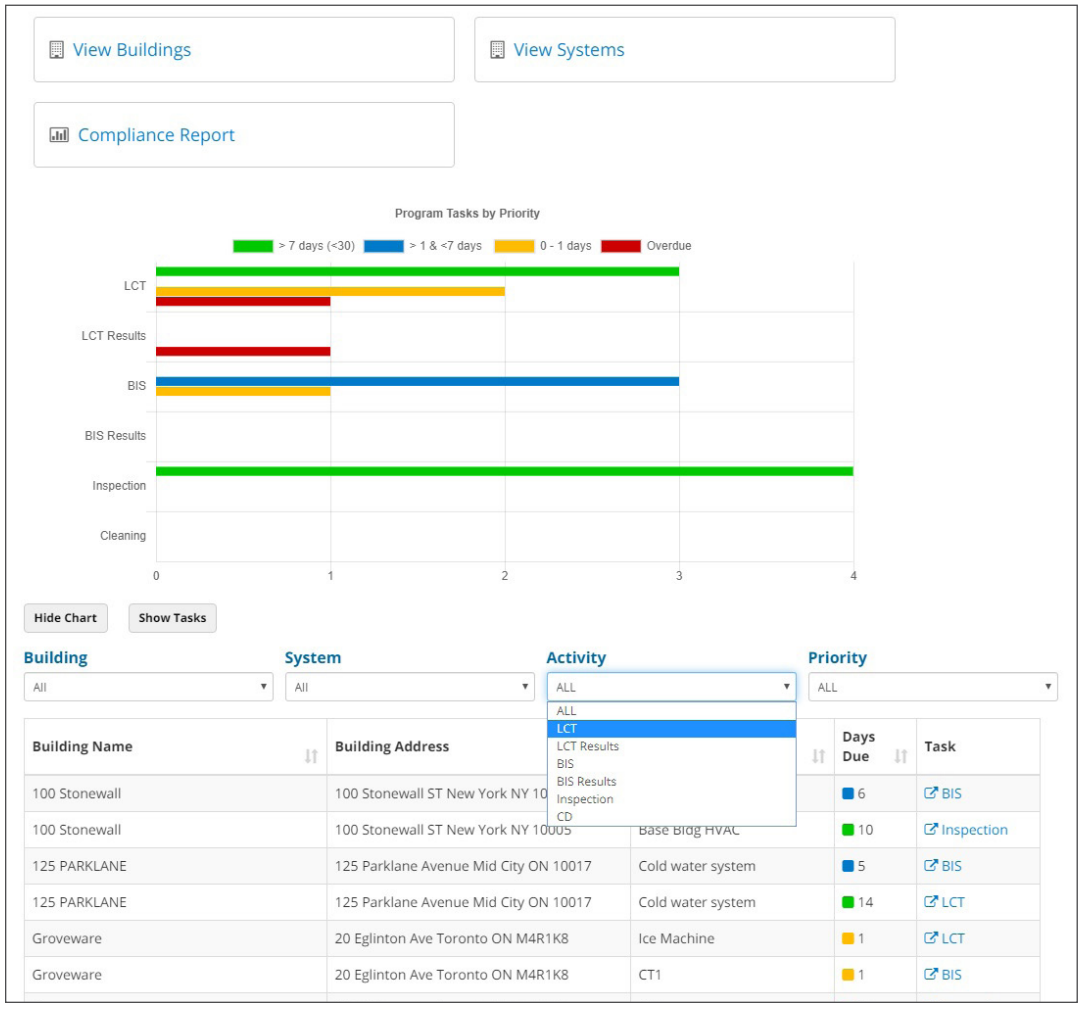


Figure 2-a. A user Portal workspace for managing assigned tasks, or activities

Task Compliance Report

Home

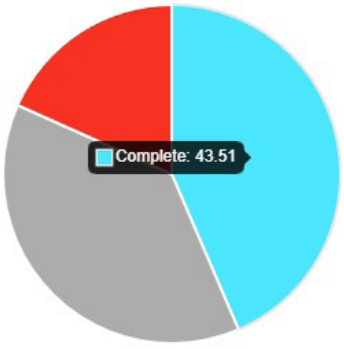
From 01/01/2019 **To** 12/31/2019

Building Groveware - 20 Eglinton Ave Toronto Of **System** All **Activity** All **Status** All

Due Date	Date Completed	Building	System	Activity	Status	Download
04/10/2019	Missed	Groveware	CT1	BIS	Missed	
05/10/2019	Missed	Groveware	CT1	BIS	Missed	
05/11/2019	Missed	Groveware	CT1	LCT	Missed	
06/03/2019	06/02/2019	Groveware	CWS 1	INSPECTION	Complete	
06/04/2019	06/03/2019	Groveware	Ice Machine	LCT	Complete	
06/04/2019	06/03/2019	Groveware	CT1	LCT	Complete	
06/04/2019	06/03/2019	Groveware	hws	LCT_RESULTS	Complete	
06/08/2019	06/07/2019	Groveware	Ice Machine	BIS	Complete	
06/08/2019	06/07/2019	Groveware	CT1	BIS	Complete	
06/08/2019	06/07/2019	Groveware	hws	BIS	Complete	
06/17/2019	06/07/2019	Groveware	Ice Machine	CD	Complete	
06/09/2019	06/08/2019	Groveware	DWF1	BIS	Complete	
06/09/2019	06/08/2019	Groveware	HWS1	BIS	Complete	
06/09/2019	Missed	Groveware	CT1	BIS	Missed	
06/10/2019	Missed	Groveware	CT1	LCT	Missed	
06/16/2019	06/15/2019	Groveware	CWS 1	BIS	Complete	
06/17/2019	06/16/2019	Groveware	hws	LCT	Complete	

Figure 2-b. Example of a User Portal workspace for compliance review

Legionella Sample Reporting



Status	Count	%
Complete	114	43.51
Late	100	38.17
Missing	48	18.32
Total	262	

Figure 2-c. Example of User Portal workspace for compliance reports

4.2 APPLICATION WORKFLOW

The application workflow depicted in the Figure 3 illustrates the main application forms and screens and the way a user will get to such functionality. Since the application is web-based, the horizontal and vertical navigation provided in the user workspace will allow the user to jump from one section to another. It is important to note that users are responsible for completing their actions (i.e. submit and save a form instance) before they move to other sections of the application in order to avoid missing data.

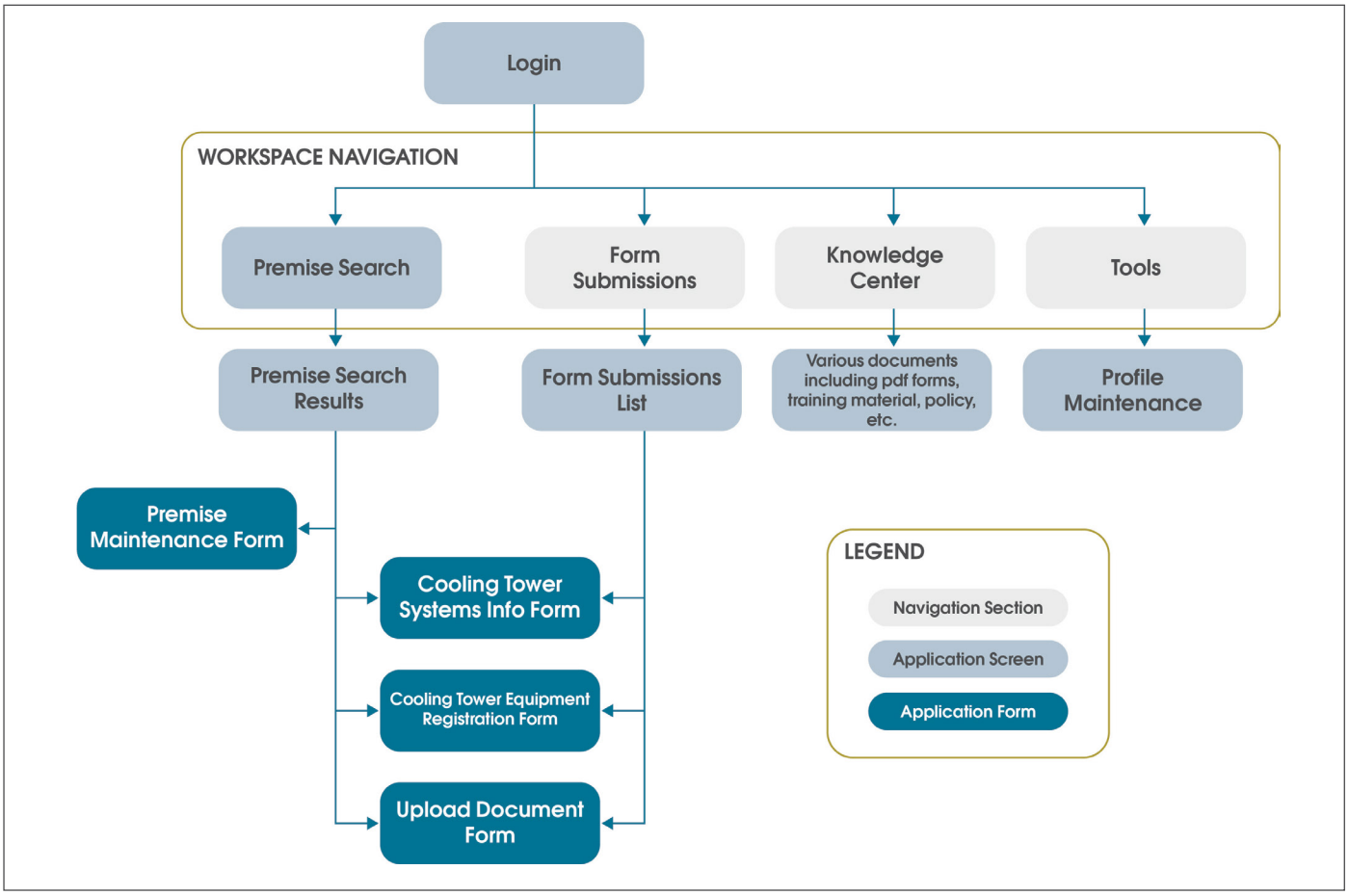


Figure 3. Application Functional Workflow

By default, when a user logs on, the "Premise Search" screen should be available in the main working window as well as the application elements grouped by the Workspace Navigation Box.

The direction of the arrows represents the flow of different user interactions within the system. They outline the necessary steps to complete certain tasks within the application. The core of the application functionality starts with the "Premise Search," from which users can complete any of the forms and/or maintain premise information. For instance, to complete a System Registration Form, a user would need to go through the following steps:

1. Login into the application
2. From the application workspace, the user will access the "Premise Search" screen
3. In the "Premise Search" screen, provide a keyword or criteria to locate the premise for which to enter the system form
4. In the "Premise Search Results," select one of the premise results to load the premise data into the "System Registration" form
5. In the "System Registration," complete the form fields and save the form to store it into the system

The options available from the vertical navigation provide the user with complementary functionality to review/edit submitted forms (View Submissions), download PDF documents associated with the Cooling Tower Portal Application (Knowledge Center) and update the user profile (Tools).

We have not included API requirements and implementation. They are unique to each organization because they contain specific endpoint communication protocols. APIs are only developed when the registration portal is set-up, all the field references are defined in the data set, and the network interface protocol is set to accept API submissions. Nevertheless, API use is desirable, and should be pursued as best practice.

Jurisdictions considering including the collection of fees as part of the CTRS Portal functionality might note that the registration system would then require a "Shopping Cart" module to be implemented. These are systems that are provided by banks and other financial institutions and require integration with a financial services organization.

The following sections describe each of the application screen/forms illustrated in the diagram and the potential actions that can be derived from them. Given the flexibility of the framework we are proposing, we cannot state which fields in each screen or form are mandated. However, some fields are required in order to ensure the functionality of the registry. Those fields are listed as "Required." Other fields can be added based on the goals and the depth of the data the jurisdiction wants to collect.

4.3 LOGIN SCREEN

This form provides functionality to capture and submit user credentials (username and password) so users can be properly authenticated and able to access the application workspace. We strongly encourage providing users the opportunity to confirm whether the equipment at their facility is actually a cooling tower or evaporative condenser by including a link that leads the user to an informative, technical description of the differences between water- and air-cooled and other systems. They can use this to determine if the equipment they have onsite requires registration. This should be made available before the user has to create a login.

i. Form Fields

FIELD NAME	FIELD TYPE	VALIDATION	REQUIRED	NOTES
Username	Text		Yes	
Password	Text	Password requirements can be set on administrative end.	Yes	Apply password mask; data must be protected from viewing
Login	Button		Yes	Submits the information in the text fields to authenticate the user
Register Now	Link		No	Link to new user registration form
Forgot Password	Link		No	Links to request password reset

4.4 USER REGISTRATION

This form captures the end user information.

ii. User Registration Form Fields

FIELD NAME	FIELD TYPE	VALIDATION	REQUIRED	NOTES
Email	Text	Email Address	Yes	
Confirm Email	Text	Email Address	Yes	
Password	Text		Yes	Apply password mask; data must be protected from viewing
Confirm Password	Text			Apply password mask; data must be protected from viewing
First Name	Text		Yes	
Last Name	Text			
Address	Text		Yes	
City	Text		Yes	
State/Province	Pulldown		Yes	
Zip/Postal Code	Text	Zip/Postal Code	Yes	
Phone Number	Text	Phone with or without extension	Yes	
Register	Button		Yes	
Cancel	Button		Yes	

4.5 BUILDING (PREMISE) REGISTRATION FORM

NOTE: Linking each cooling tower to a unique building identifier is crucial to the functionality of the registry. A jurisdiction should use the building identifier to organize all cooling tower data collected. Possible identifiers can include unique building codes; tax identification number; even geocodes.

The Manage Buildings form allows registrant to add (register) and edit (manage) information about buildings.

To add a new building, the form will be displayed with empty fields for the user to enter the information manually.

To edit an existing building, users will select one of their existing registered buildings on the form from the field at the top (Building). Once selected, the form will display that building's information with populated fields. From there, users can edit the information as needed.

Figure 4 offers an example of an existing interface for a Manage Building form. Note: this example includes fields that are system specific, and do not appear in the table below.

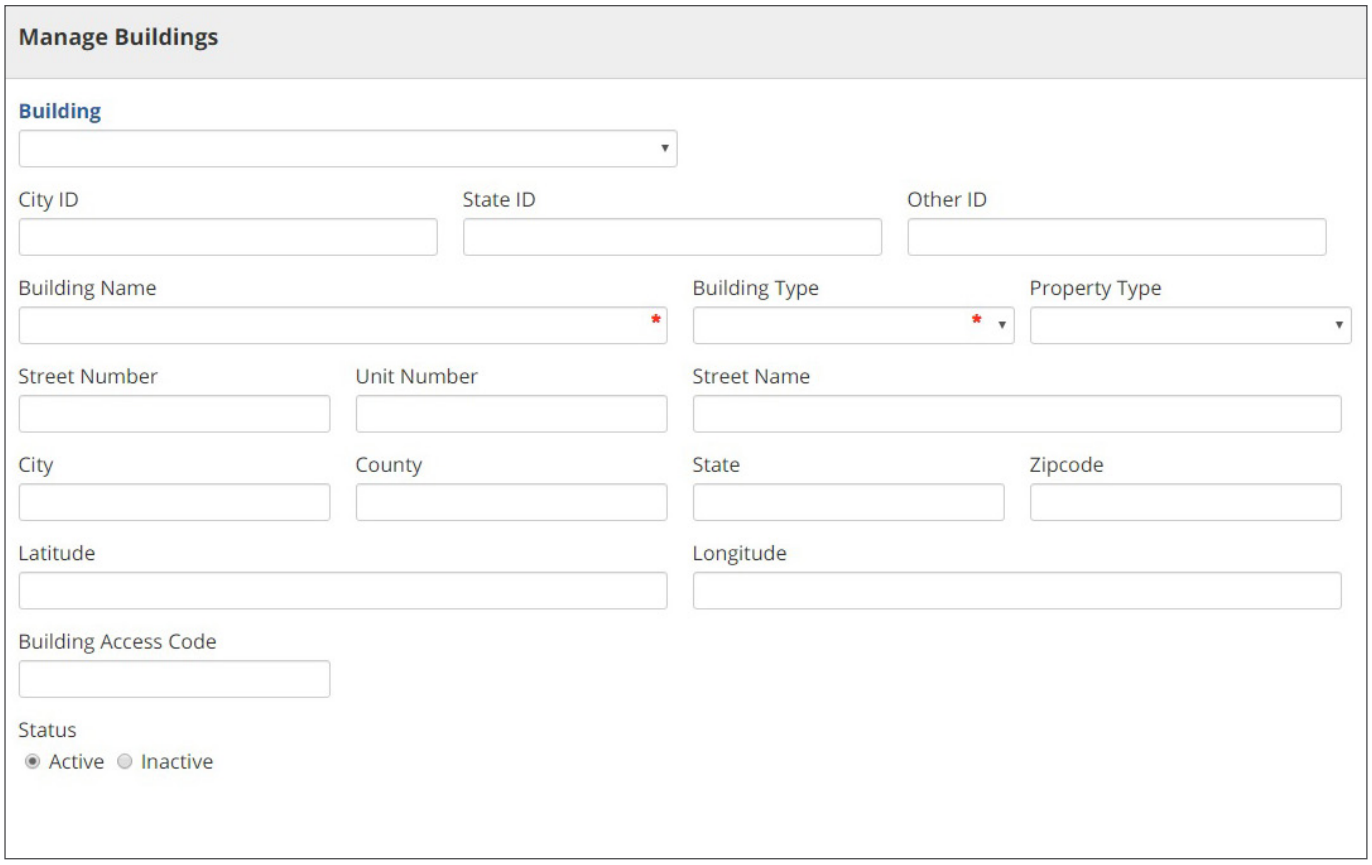


Figure 4. Sample Premise/Building Maintenance Form

iii. Manage Building Form Fields

FIELD NAME	FIELD TYPE	VALIDATION	MINIMUM REQUIRED	REQUIRED FOR COMPLIANCE	NOTES
City Building ID	Text		No	No	City Building ID for reference
State Building ID	Text		No	No	State Building ID for reference
Other ID	Text		No	No	Other Building ID for reference
Building Name	Text		Yes	Yes	Descriptor
Building Type	Pulldown		No	Yes	
Property Type	Pulldown		No	No	Public/Private
Street Number	Text		Yes	Yes	
Unit Number	Text		No	No	
Street Name	Text		Yes	Yes	
City	Text		Yes	Yes	
County	Text		No	No	
State/Province	Pulldown		Yes	Yes	
Zip/Postal Code	Text	Zip/Postal	Yes	Yes	
Latitude	Numeric			No	Required for geo-location services; best if created through look up service based on standardized address used by jurisdiction
Longitude	Numeric			No	Required for geo-location services; best if created through look up service based on standardized address used by jurisdiction

FIELD NAME	FIELD TYPE	VALIDATION	MINIMUM REQUIRED	REQUIRED FOR COMPLIANCE	NOTES
BUILDING OWNER/OPERATOR					
Type	Text		No	Yes	
First Name	Text		Yes	Yes	
Last Name	Text		Yes	Yes	
Title	Text		No	Yes	
Telephone	Text	Phone	Yes	Yes	
Email	Text	Email	Yes	Yes	
Street Number	Text		No	Yes	
Unit #	Text		No	Yes	
Street Name	Text		No	Yes	
City	Text		No	Yes	
State/Province	Pulldown		No	Yes	
Zip/Postal Code	Text	Zip/Postal	No	Yes	
Submit	Button		Yes	Yes	On click will submit the information to update/save the premise instance
Cancel	Button		Yes	Yes	On click will cancel the edit operation and return to the “Premise Search” screen

4.6 COOLING TOWER SYSTEM AND EUIPMENT REGISTRATION FORMS

Cooling Tower System

The Manage System form provides functionality to add, edit and save information about Cooling Tower System information for the registered premises/Building. If the action is "Add Cooling Tower System," the form will be displayed with empty fields for the user to complete the information. If the action is "Edit," the form will display the selected Cooling Tower information with populated fields. Users can register multiple Cooling Tower Systems against a building.

Cooling Tower Equipment

The Manage Equipment form provides functionality to add, edit and save information about Cooling Tower Equipment (Tower) for the registered Cooling Tower System. If the action is "Add Cooling Tower Equipment", the form will be displayed with empty fields for the user to complete the information. If the action is "Edit," the form will display the selected Cooling Tower information with populated fields. Users can register multiple Cooling Tower Systems against a building. Figures 5-a and 5-b are examples of existing Cooling Tower Manage Systems and Manage Equipment forms.

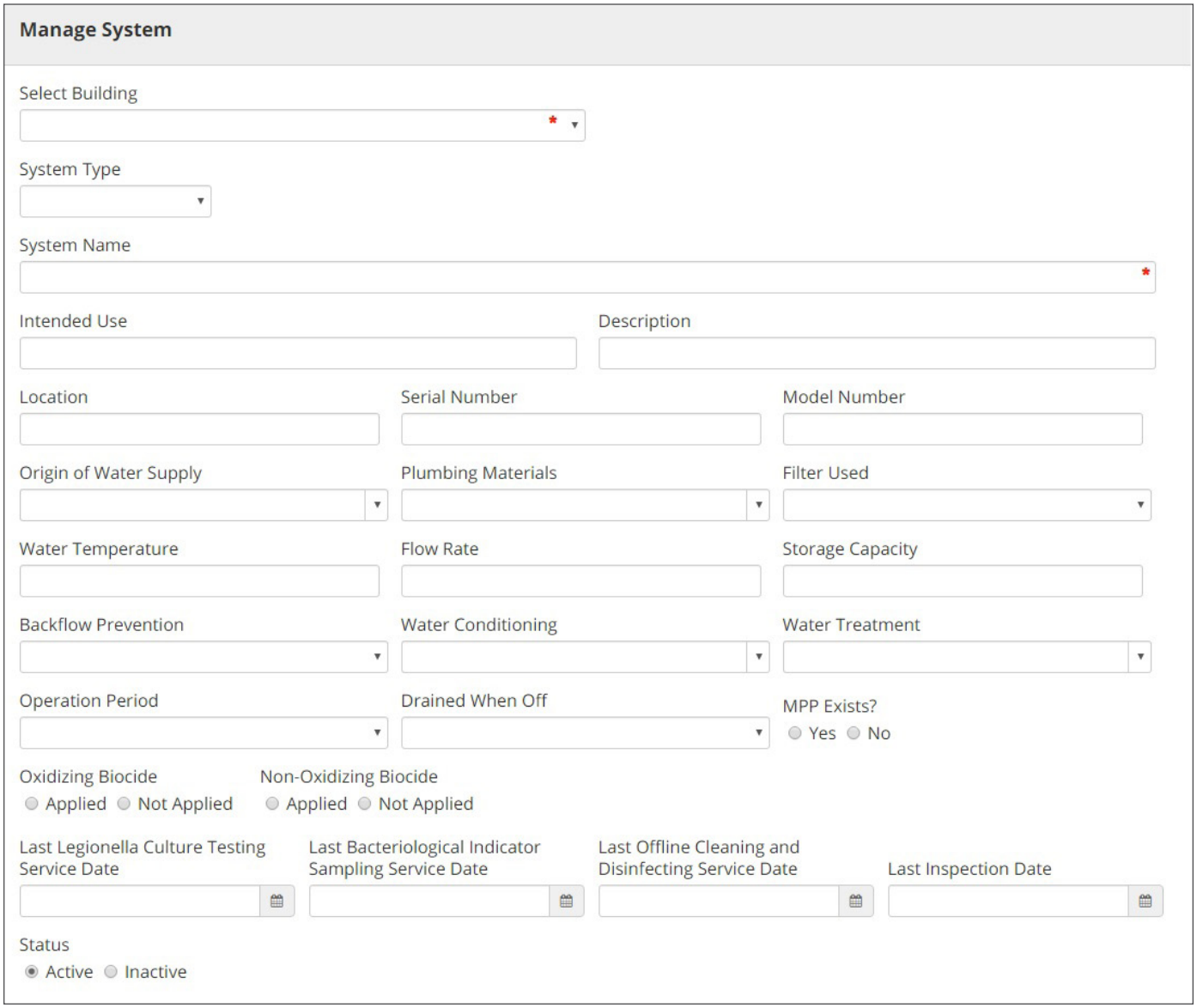


Figure 5a. Sample Cooling Tower System Information Form

Manage Equipment

Registration #

Cooling Tower Name *

Cooling Tower Type *

Location

Enclosed Status

Manufacturer

Model Number

Serial Number

Commissioned Date

Decommissioned Date

Operation Period

Operation Start Date

Operation End Date

Cooling Capacity (tonnage)

Units

Conductivity of Blowdown Water

Conductivity of Makeup Water

Initial Cycles of Concentration

Initial Makeup Water Volume

Automatic Controller Model

How is makeup water introduced?

Water meter installed on makeup line? ○ Yes ○ No

Water meter installed on blow down/bleed line? ○ Yes ○ No

Overflow alarm installed? ○ Yes ○ No

Last Cooling Tower Inspection Service Date

Last Certification Service Date

Tower Status *

◉ Active ○ Inactive (Deleted) ○ Temporary Shutdown

Figure 5b. Sample Cooling Tower Equipment Information Form

iv. Manage System and Manage Equipment Form Field

COOLING TOWER SYSTEM FIELDS "MANAGE SYSTEM"					
FIELD NAME	**FIELD TYPE**	**VALIDATION/ FIELD VALUES**	**MINIMUM REQUIRED FOR REGISTRATION**	**REQUIRED FOR COMPLIANCE**	**NOTES**
Select System	Pulldown		No	No	Reads in user's registered systems at the building
System Name	Text		Yes	Yes	Descriptor
Intended Use	Text		Yes	Yes	Use of Cooling Tower System (e.g. comfort, process, refrigeration)
Description	Text		No	Yes	Description of usage
Water Source	Pulldown		Yes	Yes	Source of the water used for Cooling Tower System
Operation Period	Pulldown	Annual Seasonal	Yes	Yes	Duration of operation
Season Start Date	Calendar	Date	Yes	No	Required for seasonal systems
Season End Date	Calendar	Date	Yes	No	Required for seasonal systems
System Volume	Text	Numeric	Yes	Yes	
Location Maintenance Program Plan	Text		No	No	
Total Recirculated Water Volume	Text	Numeric	Yes	Yes	
Total Recirculated Water Volume Units	Drop down menu (Gallons or Liters)		Yes	Yes	
Type of Biocide Control	Text		Yes	Yes	
Final Cycles of Concentration	Numeric	(Blowdown, µS/cm)/ (makeup, µS/ cm)	Yes	Yes	Calculated CoC per month/quarter/etc. Or estimated based on water sub-meter data – see Appendix A.

COOLING TOWER SYSTEM FIELDS "MANAGE SYSTEM"					
FIELD NAME	**FIELD TYPE**	**VALIDATION/ FIELD VALUES**	**MINIMUM REQUIRED FOR REGISTRATION**	**REQUIRED FOR COMPLIANCE**	**NOTES**
Make-up and Blowdown Rates	Text	Numeric	No	No	Per month/etc.
Certification Date	Text		No	Yes	
Maintained By	Text		No	Yes	
Water Treatment Company	Text		No	Yes	
Qualified Water Treatment Applicator	Text		No	Yes	
First Name	Text		No	Yes	
Last Name	Text		No	Yes	
Initials	Text		No	Yes	
Title	Text		No	Yes	
Date of Certification	Calendar		No	Yes	
Telephone	Text	Phone (with or without extension)	No	Yes	
Email Address	Text	Email	No	Yes	
Status	Radio Dial	Active	No	Yes	Database status of Cooling Tower System
Number of Cooling Tower(s) (Equipment)	Text	Inactive	No	Yes	

COOLING TOWER SYSTEM FIELDS "MANAGE EQUIPMENT"					
FIELD NAME	**FIELD TYPE**	**VALIDATION/ FIELD VALUES**	**MINIMUM REQUIRED FOR REGISTRATION**	**REQUIRED FOR COMPLIANCE**	**NOTES**
Cooling Tower Name	Text		Yes	No	Per month/etc.
Cooling Tower Manufacturer	Text		No	Yes	
Cooling Tower Location	Text		Yes	Yes	
Cooling Capacity	Text	Numeric		Yes	
Cooling Capacity units	Pulldown	Tons BTU Other	Yes	Yes	
Conductivity of Blowdown Water	Text	Numeric	No	Yes	
Conductivity of Makeup Water	Text	Numeric	No	Yes	
Initial Cycles of Concentration	Text	Numeric (Blowdown, µS/cm)/(makeup, µS/cm)	No	Yes	
Initial Make-up Water Volume	Text	Numeric	No	Yes	
Commission Date	Calendar	Date	No	Yes	
Decommission Date	Calendar	Date	No	No	
Seasonality	Radio Dial	Annual Seasonal	Yes	Yes	
Automatic Controller Model	Text		No	Yes	
Water meter installed on makeup line?	Radio Dial	Yes No	No	Yes	
Water meter installed on blowdown/	Radio Dial	Yes No	No	Yes	

COOLING TOWER SYSTEM FIELDS "MANAGE EQUIPMENT"					
FIELD NAME	**FIELD TYPE**	**VALIDATION / FIELD VALUES**	**MINIMUM REQUIRED FOR REGISTRATION**	**REQUIRED FOR COMPLIANCE**	**REQUIRED FOR COMPLIANCE**
Overflow alarm installed?	Radio Dial	Yes No	No	Yes	
How is makeup water introduced?	Drop down (float valve in basin/other)		No	Yes	
Legionella Sample Date	Date	Date	No	Yes	Submitted at frequency determined by jurisdiction
Legionella Sample Result	Numeric	cfu/ml	No	Yes	Submitted at frequency determined by jurisdiction
Legionella Sampling Date	Calendar	Date	No	Yes	
If you have an Exceedance in your results	Radio Dial	Yes/no	No	Yes	On click will submit the information to update/save the premise instance
Sample Date	Calendar	Date	No	Yes	
Tests Performed	Text		No	Yes	
Lab Name	Text		No	Yes	
Lab Reference #	Alpha Numeric		No	Yes	
Sample Result	Numeric	cfu/ml	No	Yes	
Concentration	numeric		No	Yes	
Species	Text		No	Yes	
Document Upload			No	Yes	Upload Lab Results
Submit	Button			Yes	On click will submit the information to update/save the premise instance
Cancel	Button			Yes	On click will cancel the edit operation and return to the "Premise Search" screen

4.7 SUSTAINABILITY INSPECTION KEY PERFORMANCE INDICATORS (KPIs)

All cooling tower systems should be inspected by a third-party independent of the vendor responsible for the day to day management of the cooling tower system. During routine inspections, the following parameters should be inspected for and recorded on a template log sheet. The inspection log detailing the condition of each component should be uploaded to the portal:

- Proper functioning and calibration of meters on make-up and blowdown lines
- Proper water level in sump and float placement to prevent overflow
- Conductivity controller operating and calibrated
- Presence of biofouling, corrosion, scale collection, and sediment buildup on system components
  - Fill materials
  - Spray nozzles
  - Basin/sump
  - Heat exchanger
  - Drift eliminators
- Inspection of chemical injection system and associated controls
- Presence of leaks in tower basins, flexible connections, pump gland seals, and control valves
- Optimal water distribution through fill material

In order for the registry to calculate water savings for each cooling tower, the user needs to input the initial and final cycles of concentration. See below for the calculation for water savings.

v. KPI Form Fields (key parameters can be collected on-site)

FIELD NAME	FIELD TYPE	REQUIRED	NOTES
Volume of makeup water	Text	Yes	
Volume of blowdown water	Text	Yes	
Target cycles of concentration	Text	Yes	
Actual cycles of concentration	Text	Yes	
Conductivity of blowdown water (µS/cm)	Text	Yes	
Conductivity of makeup water (µS/cm)	Text	Yes	

OTHER PARAMETERS	FIELD TYPE	REQUIRED	NOTES
pH	Text	No	
Hardness (ppm as Calcium Carbonate)	Text	No	
Corrosion	Text	No	

Once collected, the key sustainability parameters can be incorporated into the following equation to calculate water savings:

- V = M x ((C2 – C1)/(C1 x (C2 – 1))
- V = volume of water saved
- M = initial make-up water volume
- C1 = Initial cycles of concentration
- C2 = Final cycles of concentration

Other parameters

- pH
- Hardness (ppm as Calcium Carbonate)
- Corrosion (mils/year or microns/year)

4.8 DOCUMENT/CERTIFICATE UPLOAD

This form is to be used to upload documents. A user may select any of the possible document types to obtain more information about the document and download a copy (see notes on Document Upload Form Fields table for examples). Allow multiple documents to be uploaded simultaneously, up to ten at a time. Figure 6 is an example of an existing Document Upload page.

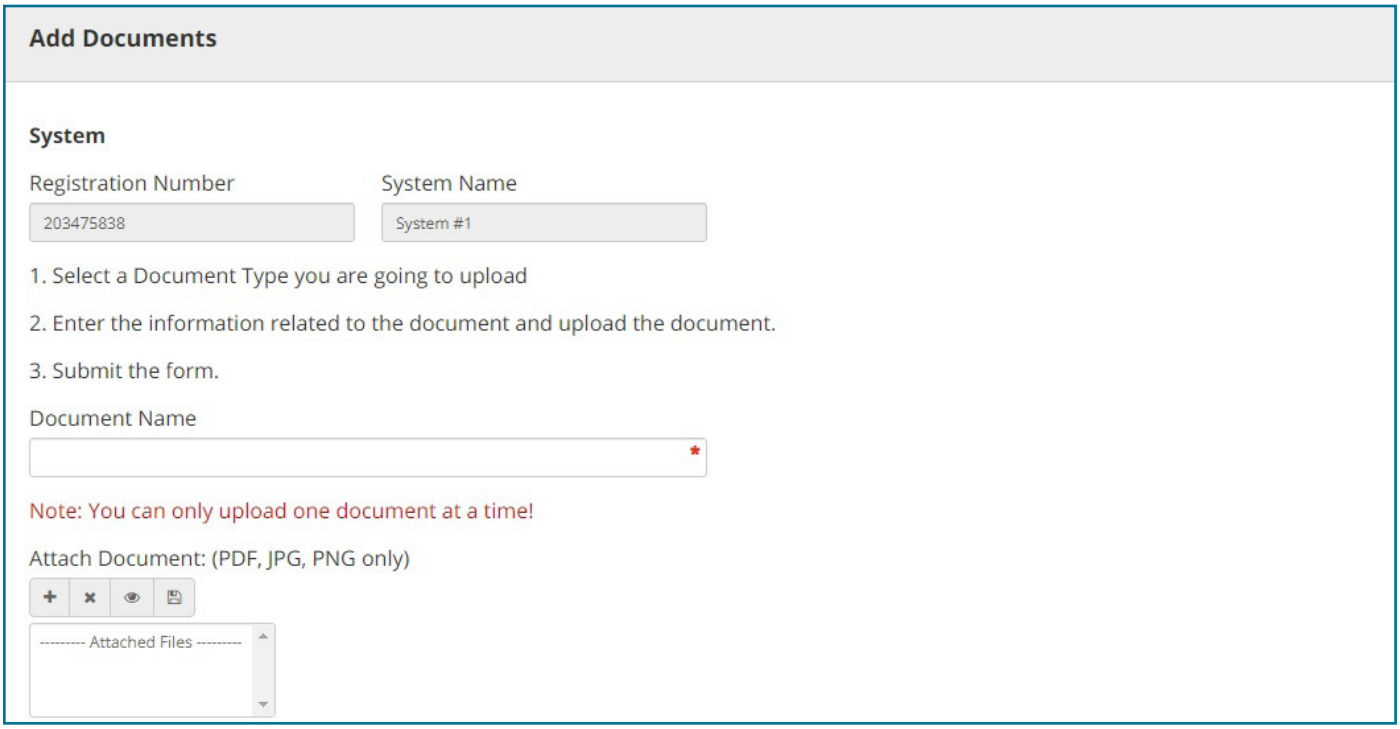


Figure 6. Sample Document Upload Form

vi. Document Upload Form Fields

FIELD NAME	FIELD TYPE	VALIDATION	REQUIRED	NOTES
Building Registration Number	Text		Yes	
System Name	Text		Yes	
Number of Documents to be Uploaded	Pulldown	1-10	Yes	Selected Drop-down number causes additional rows to appear that require the information for each document.
Document Type	Radio Dial		Yes	Annual Certification, Inspection Results per [week/month/quarter], Proper functioning and calibration of meters on make-up and blowdown lines, Proper overflow prevention, Sample Results, Proof of Disinfection , Other: (opens text box when selected)
Document Name	Text		Yes	
File Attachment			Yes	

4.9 BUILDING/PREMISE SEARCH

This view provides the functionality to perform a building search and view results by capturing the search criteria and submitting it to the registry to retrieve search results. This returned value displays the search results for buildings that match the search criteria. A user can decide to update information for a selected premise, add a new premise if there are no matching results, or select an Inspection Form in which the selected premise data will be loaded. Figures 7 and 8 are examples of existing Building Search and Search Result screens, respectively.

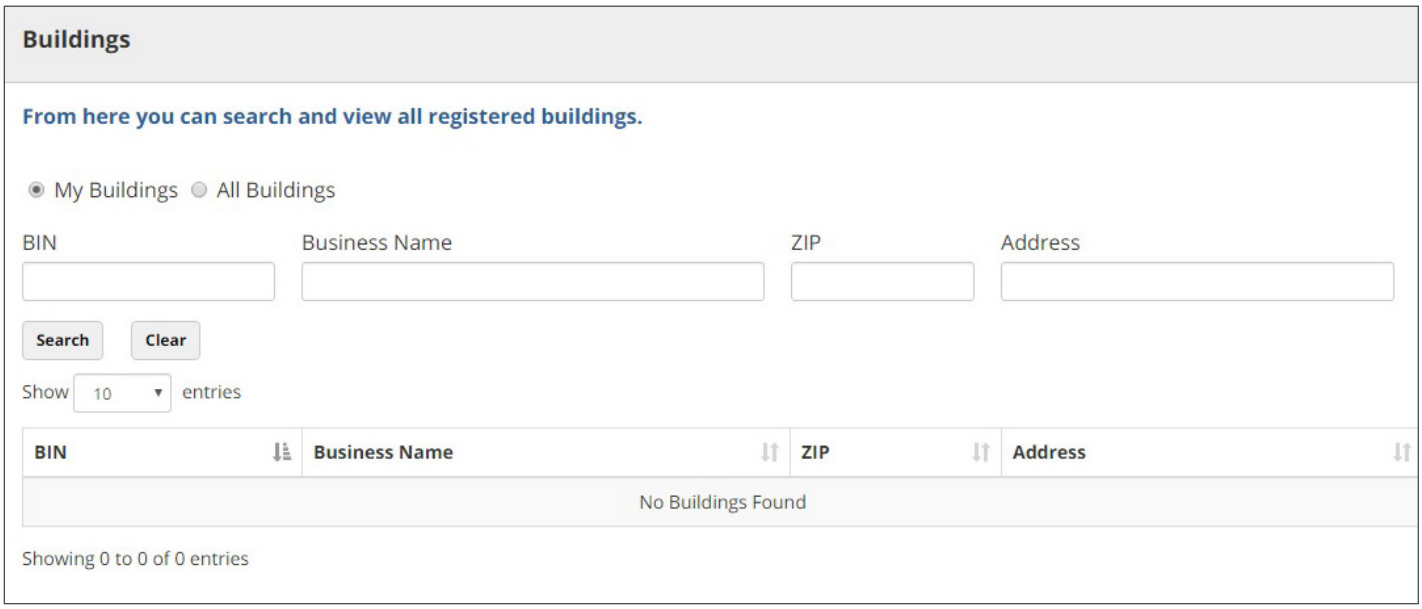


Figure 7. Sample Building/Premise Search Screen

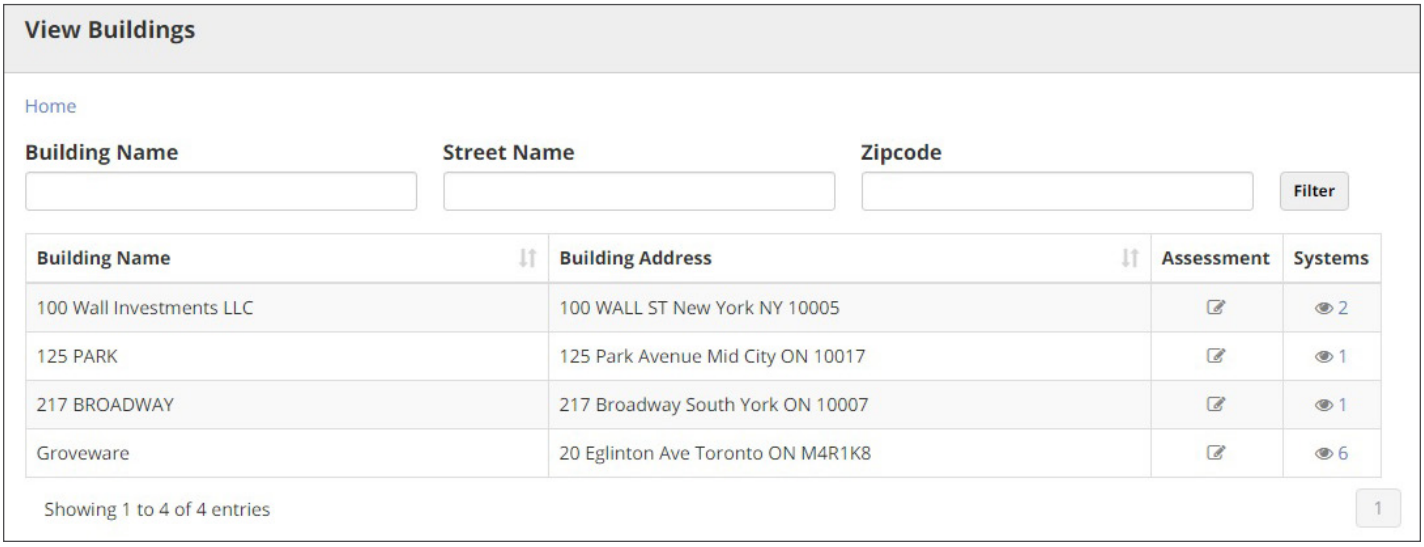


Figure 8. Sample Building/Premise Search Results Screen

vii. Building/Premise Search Form Fields

FIELD NAME	FIELD TYPE	VALIDATION	NOTES
Search by Building Identification Number (BIN)	Filter		
Building Operating Name/ Business Name	Filter		
Legal Name	Filter	1-10	It will only be used if “Search by Building Identification Number” is selected
Street Address	Filter		It will only be used if “Building Operating Name” is selected.
Zip Code/ Postal Code	Filter		It will only be used if “Building Operating Name” is selected.

FIELD NAME	FIELD TYPE	VALIDATION	NOTES
City/Town	Filter		It will only be used if “Building Operating Name” is selected.
Edit Premises/ Building Information	Link		Once a premise has been selected this link will open the Premise Maintenance Form for editing the selected premise information. If there is no premise selected, the system will display a message to indicate to the user they should select a premise.
Add a New Premise/Building	Link		If the results retrieve 0 premises, or a premise is not found, the user can click on this link to jump to the Premise Maintenance Form and create a new premise.
List of Building Identification Numbers	Text	Read Only	Table Column 1
Operating Name	Text	Read Only	Table Column 2
Zip/Postal Code	Text	Read Only	Table Column 3
Address Details	Text	Read Only	Table Column 5
			Table Column 3
			Table Column 5

4.10 KNOWLEDGE CENTER (ITEMS)

This menu provides access to a list of documents available in the system. A user may select any of the documents to obtain more information about the document and download a copy. If the jurisdiction chooses to enact regulations for the registration/management of the cooling tower systems, the Knowledge Center should always contain the updated version of the regulations/law, as well as any guidance documents.

The Knowledge Center should have a function for the user to be able to upload their own informational documents in addition to what the jurisdiction has available. This would be useful for users to upload .pdf tower/system specifications, maintenance plans, or any other documents they would like for easy access and reference. These documents would not be accessible by the jurisdiction.

viii. Message Center

This window should provide the user access to any and all messages the jurisdiction has sent out to either all users or just individual users. In addition to sending an email to the registered user, the same message should appear in the portal for easy viewing/tracking of messages and correspondence with the jurisdiction. Figure 9 is an example of an existing Knowledge Center screen.

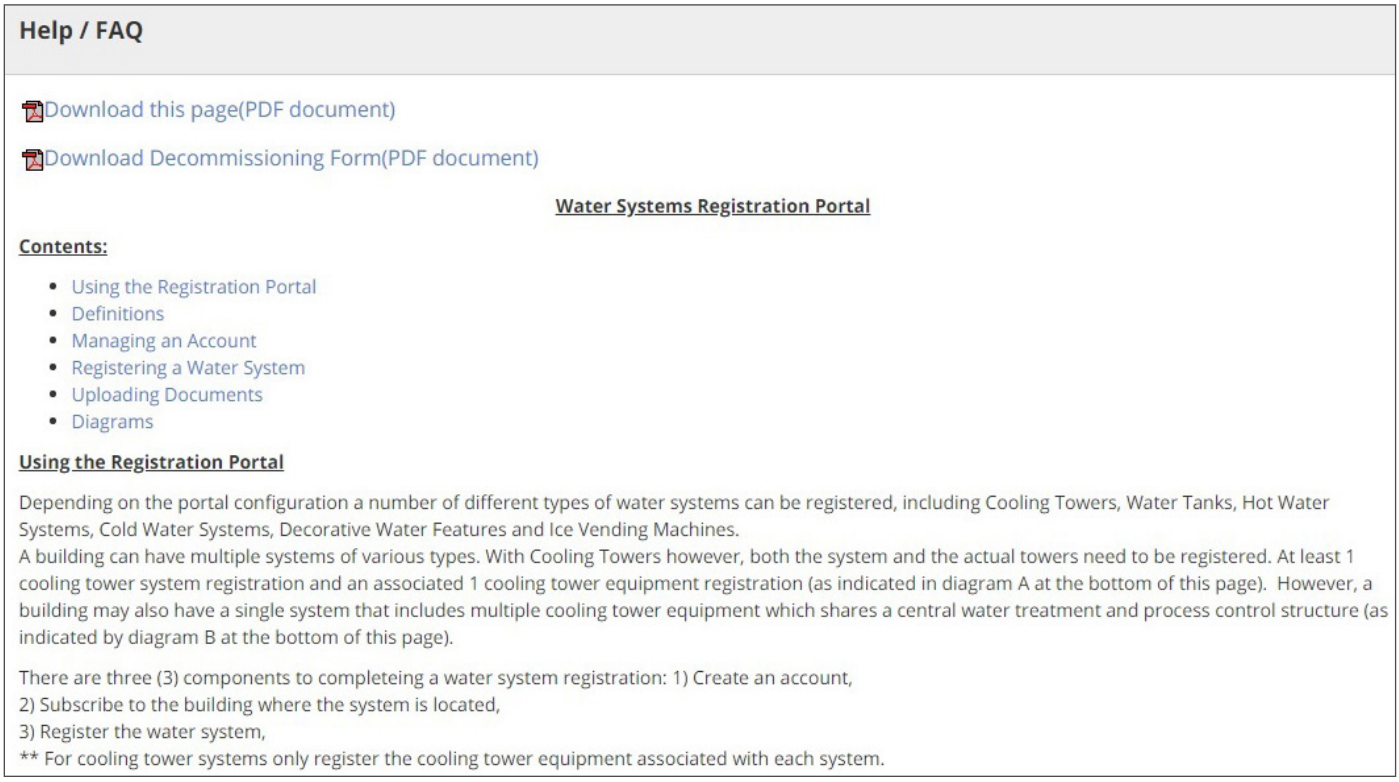


Figure 9. Sample Knowledge Centre

vii. Building/Premise Search Form Fields

FIELD NAME	FIELD TYPE	VALIDATION	NOTES
Name	Text	Read Only	Document Name
Description	Text	Read Only	Document Description
Documents	Link		On click this link will download and present the document to the user.
Notes	Text	Read Only	
Author of comment	Text	Read Only	User uploading the document to the Knowledge Centre. Only the administrator will upload documents to the Knowledge Centre. Read Only
Date	Text	Read Only	Upload Date

4.11 TOOLS: PROFILE MANAGEMENT

This menu provides access to the user profile. A user will be able to update her password and other personal information. Figure 10 is an existing example of a Profile Management screen.

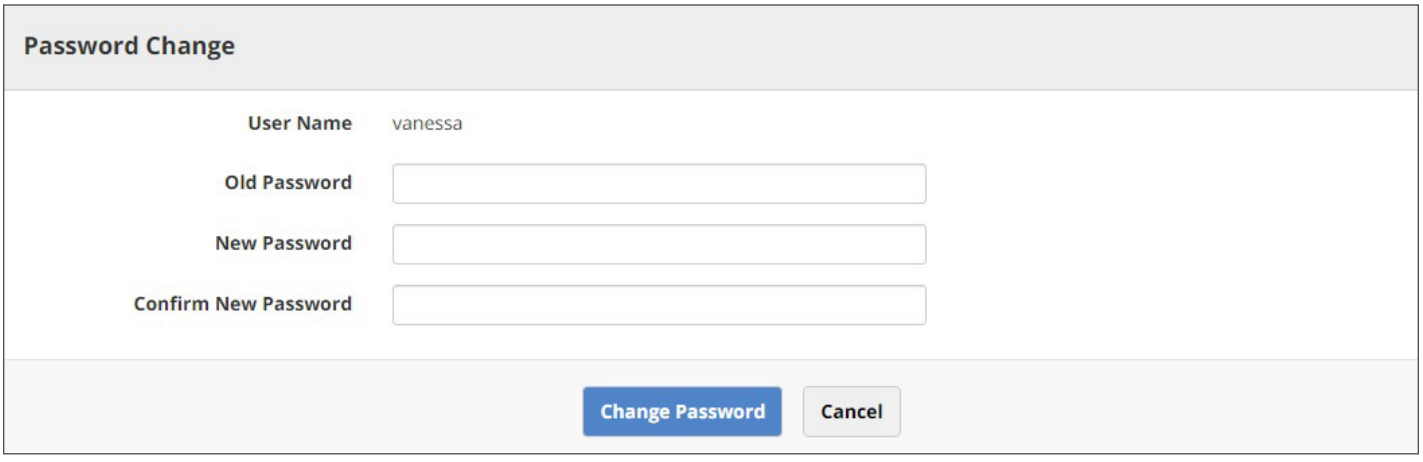


Figure 10. Sample Tools (Profile Maintenance)

4.12 TOOLS: COMMUNICATION AND REQUEST

The communication interface allows users within the system (registrants and administrators) to communicate and logs the communication for them. The process is initiated by registrants who open a request, and is followed by administrators who open the request to respond to it. Administrators and registrants manage the communication using the Communication Log interface. Figures 11 and 12 are examples of existing communication log and request screens.

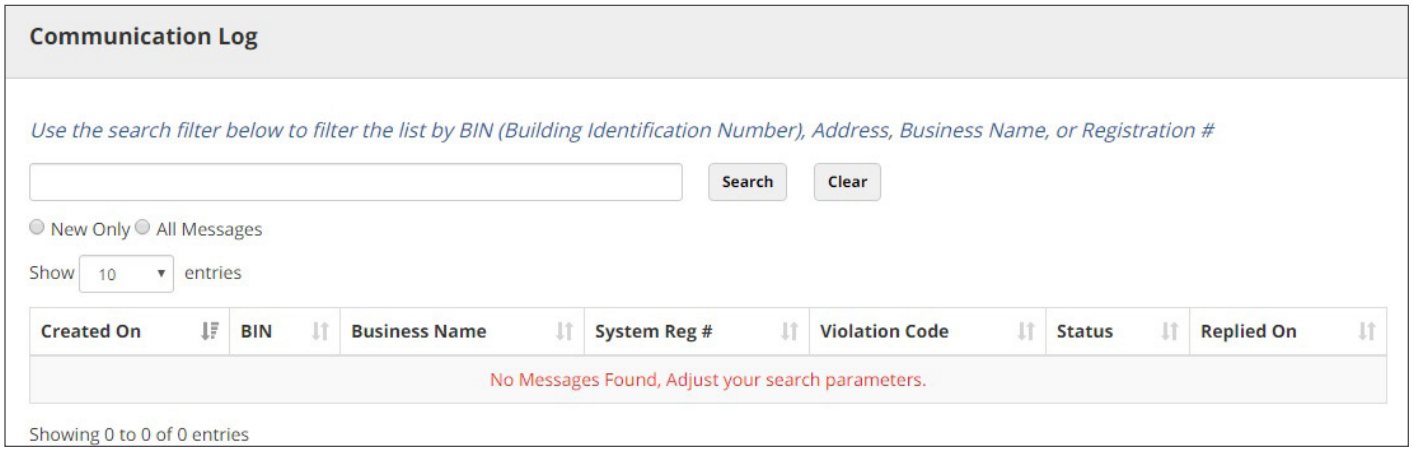


Figure 11. Sample Tools (Communication Log)

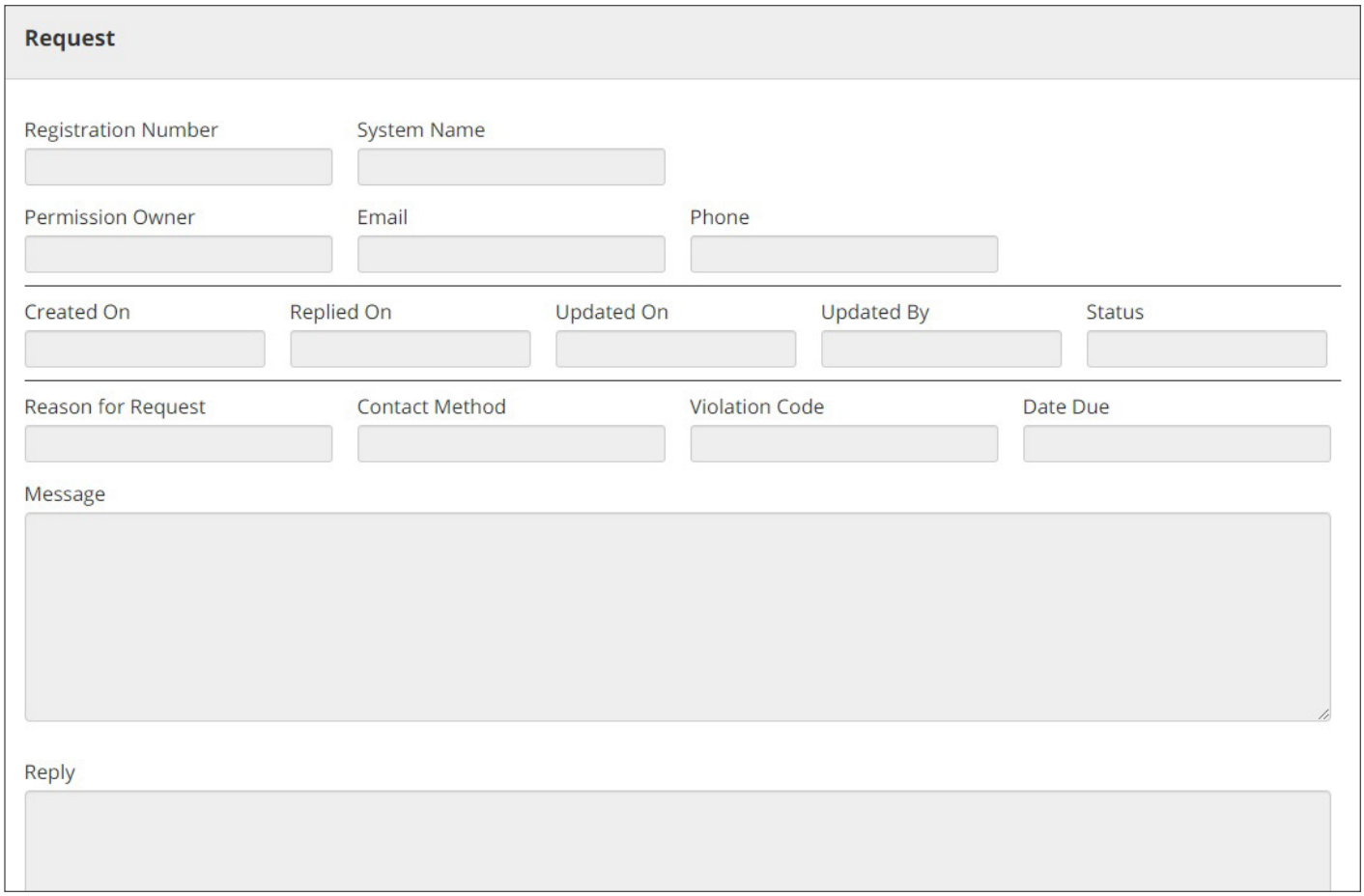


Figure 12. Sample Tools (Communication & Request)

x. Form Fields

FIELD NAME	FIELD TYPE	VALIDATION	NOTES
Premises/Building Identification #	Text	Read Only	Auto-populated
Registration Number	Text	Read Only	Auto-populated
Cooling Tower System Name	Text	Read Only	Auto-populated
Permission Owner	Text	Read Only	Auto-populated
Email	Text	Email	Can be auto-populated by user account or left for manual entry
Phone number	Text	Email	Can be auto-populated by user account or left for manual entry
Created On	Text	Read Only	Date created Auto-populated
Replied On	Text	Read Only	Date created Auto-populated
Updated On	Text	Read Only	Date created Auto-populated
Updated By	Text	Read Only	Name of the admin user who responded Auto-populated
Status	Text		Entry by admin user (response)
Reason For Request	Text		Entry by registrant user (response)
Contact method	Text		
Violation Code	Text		
Date Due	Text		
Message	Text Area		Entry by admin user (response)
Reply	Text Area		Entry by registrant user (response)

FIELD NAME	FIELD TYPE	VALIDATION	NOTES
Blank text field	Filter	Read Only	Filter by BIN (Building Identification Number) Address, Business Name, or Registration #
Created On	Returned Value	Read Only	Field value for that record
BIN	Returned Value	Read Only	Field value for that record
Business Name	Returned Value	Read Only	Field value for that record
System Registration #	Returned Value	Email	Field value for that record
Violation Code	Returned Value	Email	Field value for that record
Reason	Returned Value	Read Only	Field value for that record
Status	Returned Value	Read Only	Field value for that record
Created by	Returned Value	Read Only	Field value for that record
Replied On	Returned Value	Read Only	Field value for that record

4.13 SECURITY AND ACCESS

xi. Portal Access Objects

A core design requirement is that the portal solution secures information and functionality to specific end-user groups. The specific **Portal Objects** that must be secured are as follows:

- Navigation control
- Administrative interface access
- Access to Categories of information
- Access to Forms and data collection
- Access to data & Document that will be submitted
- Form access and data modification rights

This specifically includes such features as the options available on drop down menus and the dynamic disabling of navigation features and access to forms.

Permissions need to be assigned to users or groups for the objects that apply. For submissions and documents, permissions are assigned to groups. For workflow, permissions are assigned based on a combination of workflow role and users/groups.

xi. Security

The security of the Cooling Tower Registration portal should be set up following these directions:

- Administrators of the Registration portal application will be the only role with access to the administrative interface. Administrators will have access to all application functionality including configuration of the Portal application, and Cooling Tower Registration functionality.
- There will be three types of users; Administrators (System & Application), Building owners/Management and Public. Administrators and Building Owners/Management will submit premise/building information and corresponding cooling Tower System and Equipment details. They will be able to perform the tasks specified in the User Interface Design section of this document.
- Security will be enforced on data access so:
  - Building owners/managers can only access data of their own Premises that they have created within their organization. They will not be able to view, edit or delete information entered by other users.
  - Application administration can only access information on all Premises/Buildings.

4.14 AUTHENTICATION AND AUTHORIZATION

The sign-on and authentication of users with the form solution is provided by the Portal security module. The Portal should use a secure socket layer certificate protocol (https). All users' credentials should be stored in database encrypted passwords. Users are authenticated by providing their username and password on a web-based login screen. The portal should support integration with standard Lightweight Directory Access Protocol (LDAP) for authentication purposes if a migration of users to a directory service is required in the future.

4.15 ADMINISTRATION

Portal administration should be managed through an Internet browser interface to make basic administrative tasks convenient, including:

- **User administration**
- **User group administration**
- **Permission administration**
- **System administration**

User administration involves the creating and deleting of users and assigning users to user groups. **User group administration** involves the creating and deleting of user groups. **Permission administration** allows a privileged user (and administrator) to edit a group or user and specify permissions of the portal.

System administration involves the editing of system variables that are not related to the business solution. Its rules and requirements must be defined by the organization for view online users, system monitoring, database lookup settings, system preferences, index databases, and other applications.

APPENDIX A:
Sustainability and Public Health Risk Measures/Expectations

1. Initial Makeup Water Volume, M

- Definition: Makeup water is water added to the cooling tower system to replace water lost by evaporation, blowdown, drift, and other water losses.
- Units: Gallons or liters
- User: Monitoring performed by building staff.
- Hardware/software requirements:
  - Continuous measurement using a dedicated meter: Volume of water logged by the metering system over a time interval.
  - Ultrasonic or other short-term meter: Data should capture the full measurement period or for a duration that includes full range of operating conditions (i.e. from low cooling demand to peak design demand)
- Communication interfaces: Data logging capability that allows for collection of volumetric water use over distinct intervals (e.g. 15 min, 1 hr). In-line meters should be connected to a centralized control system or an online database.

2. Cycles of Concentration

- Definition: Cycles of concentration (COC) refers to the ratio of the conductivity of the blowdown water to the conductivity of the make-up water. This is also equivalent to the ratio of make-up water volume to blowdown water volume. Initial COC or C1 is identified at the beginning of a water management plan, or at a reference point prior to optimizing water chemistry. Actual COC or C2 is calculated when system is operational.
- Units: (Blowdown, µS/cm)/(makeup, µS/cm)
- User: Monitoring performed and calculated by water treatment vendor
- Hardware/software requirements: Conductivity controllers manage the COC in the tower system. Continuously measure the conductivity of the recirculating water and actuates the blowdown to a programmed setpoint.
- Communication interfaces: Actual COC determined by the database and input into the portal.

3. Conductivity of Blowdown Water (µS/cm)

- Definition: Conductivity measurement is used to estimate the amount of total dissolved solids (TDS) in the recirculating cooling water. Conductivity is used to initiate blowdown, thereby managing TDS levels and determining COC.
- Units: µS/cm (mmhos/cm)
- User: Monitoring performed and managed by water treatment vendor
- Hardware/software requirements: Conductivity probes can continuously track the total dissolved solids in the blowdown water. Handheld conductivity meters can also be used to collect data that is then input manually into the portal.
- Communication interfaces: Conductivity measurements transmitted back to the integrated control system or portal.

4. Conductivity of Makeup Water (µS/cm)

- Definition: Conductivity measurement is used to estimate the amount of total dissolved solids (TDS) supplied in the makeup water.
- Units: µS/cm (mmhos/cm)
- User: Monitoring performed and managed by water treatment vendor
- Hardware/software requirements: Conductivity probes can continuously track total dissolved solids in the makeup water. Handheld conductivity meters can also be used to collect data that is then input manually into the portal.
- Communication interfaces: Conductivity measurements transmitted back to the integrated control system or portal.

5. pH

- Definition: Measurement of how acidic or how alkaline a substance is on a scale of 0-14. The pH of cooling water is typically maintained in the alkaline range, which is > 7.0. Undesirable rates of corrosion can occur at both higher and lower pH, depending on the material of construction.
- Units: Numerical

- User: Monitoring performed and managed by water treatment vendor
- Hardware/software requirements: pH probes can continuously monitor pH levels of the recirculating water over time. Handheld pH meters can also be used to collect data that is then input manually into the portal.
- Communication interfaces: pH measurements transmitted back to the integrated control system or portal

6. Hardness

- Definition: Presence of dissolved calcium and magnesium in cooling tower water. Both minerals can form deposits on heat exchangers or the warmest areas of the tower (e.g. top region of the fill).
- Units: parts per million (ppm) of calcium carbonate, ppm of magnesium hydroxide
- User: Monitoring performed and managed by water treatment vendor
- Hardware/software requirements: Digital colorimeter or water quality test kits that are able to monitor calcium hardness and total hardness
- Communication interfaces: Hardness measurements entered manually into the portal.

7. Corrosion

- Definition: Loss of base metal in a system caused by saturation of water with oxygen. Corrosion byproducts can enter the bulk water stream as suspended solids and can reduce the flow through piping.
- Units: Corrosion potential (mils/year)
- User: Monitoring performed by water treatment vendor or by on-site staff
- Hardware/software requirements: Pre-weighed ASTM corrosion coupon racks or permanent probes.
- Communication interfaces: Manual input of corrosion potential after 30-90 days of installation, or immediate input from installed probes.

8. Proper functioning and calibration of meters on make-up and blowdown lines

- Definition: All dedicated meters and temporary meters that are used to measure the volume of water from make-up and blowdown water lines must be working, accurate, and communicate data to the central data system.
- Data input: Date of last inspection, date of last calibration; Acceptable or Not Acceptable condition
- User: Third-party vendor
- Hardware/software requirements: Manual input of data into the portal. Inspection log uploaded to the portal.

9. Proper water level in sump and float placement to prevent overflow

- Definition: Maintaining a consistent water level in the cooling tower sump will prevent overflow from the tower, a significant cause of water loss.
- Data input: Date of last inspection; Water Level: High, Optimal, Low
- User: Third-party vendor
- Hardware/software requirements: Manual input of data into the portal. Completed template inspection log uploaded to the portal.

10. Conductivity controller operating and calibrated

- Definition: Conductivity controllers should be calibrated at a frequency determined by the manufacturer to ensure proper control of automatic blowdown and tracking of TDS in the makeup and recirculating water.
- Data input: Date of last calibration; Acceptable or Not Acceptable condition
- User: Third party vendor
- Hardware/software requirements: Manual input of data into the portal. Completed template inspection log uploaded to the portal.

11. Presence of biofouling, corrosion or scale collection, sediment buildup on system components

- Definition: Chemical or biological fouling on components of the cooling tower system can have a large effect on the ability of system components to operate efficiently. Routine inspections should identify the presence of hazardous conditions that can cause water loss, reduction in heat transfer, or increases in makeup water demand.
- Data input: Date of last inspection. Fill material, spray nozzles, basin/sump, heat exchangers, and drift eliminators should be inspected. For biofouling, corrosion/scale collection, sediment buildup, identify whether the condition is a) absent b) light c) moderate d) significant.
- User: Third-party vendor
- Hardware/software requirements: Manual input of data into the portal. Completed template inspection log uploaded to the portal.

12. Inspection of chemical injection system and associated controls

- Definition: The system that injects chemicals into the cooling tower system should be inspected for leaks from the chemical drum and in the lines, connections to the system, and control mechanisms (either automatic or manual) that dose the system water and monitor the residuals.
- Data input: Date of last inspection. Acceptable or Not Acceptable condition
- User: Third-party vendor
- Hardware/software requirements: Manual input of data into the portal. Completed template inspection log uploaded to the portal.

13. Presence of leaks in tower basins, flexible connections, pump gland seals, and control valves

- Definition: Leaks from cooling tower system components contribute greatly to the overall water loss in the system.
- Data input: Date of last inspection. Acceptable or Not Acceptable condition. Confirmation of location of leak.
- User: Third-party vendor
- Hardware/software requirements: Manual input of data into the portal. Completed template inspection log uploaded to the portal.

14. Optimal water distribution through fill material

- Definition: The components of the cooling tower that causes the circulating water to spread out over a large surface area in order to increase the evaporation rate by exposing the water to a greater volume of air. If water cascades unevenly down the fill, the fill material will be prone to biological buildup which will reduce the efficiency of the system to expel heat.
- Data input: Date of last inspection. Acceptable or Not Acceptable condition.
- User: Third-party vendor
- Hardware/software requirements: Manual input of data into the portal. Completed template inspection log uploaded to the portal.

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[3] Farnham et al. (2014) "Legionnaires' Disease Incidence and Risk Factors, New York, New York, USA, 2002-2011" *Emerging Infectious Diseases* 20(11).

[4] National Academies of Sciences, Engineering, and Medicine. 2019. *Management of Legionella in Water Systems*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25474.

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[13] Smith, D (2016) "High Rises Harbor Little Noticed Water Waster: Old Cooling Towers" Los Angeles Times, Jan 12. https://www.latimes.com/local/california/la-me-cooling-towers-20160102-story.html Accessed December 20, 2019

[14] See WRF Project 4664 "Customer Messaging on Opportunistic Pathogens in Plumbing Systems" for more information. https://www.waterrf.org/research/projects/customer-messaging-opportunistic-pathogens-plumbing-systems for more details.

[15] A list of national registries appears in Parr et al (2015) Legionellosis on the Rise: A Review of Guidelines for Prevention in the United States *Journal of Public Health Management and Practice*. 21(5): E17–E26, September/October

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