Bowtie-Q™ Quantitative Bowtie Analysis

User's Manual

Rev 0

Introduction

This guide describes how to use the Bowtie-Q™ Software. Bowtie-Q™ is a module in the Kenexis Integrated Safety Suite (KISS). KISS provides technical safety professionals with a cloud-based enterprise multi-user platform for the performance and documentation of technical safety and risk analysis activities.

Because new features are added frequently, you are encouraged to check the version number on the cover page of this manual to ensure that you are reading the most current version of this manual which corresponds with the active version of Bowtie-Q™.

About Kenexis

Kenexis is an independent engineering consulting and software development firm. We ensure the tolerability of risk in the design of industrial facilities. Using skills in risk analysis, reliability engineering, and process engineering, we help establish the performance standards for safety critical equipment items that ensure tolerable levels of risk are achieved.

Table of Contents

Introduction 2

About Kenexis 2

0.1 Definitions 6

1.1 Instructions for First Time Login 7

1.2 Login Troubles 9

1.3 Other Resources 11

2.1 The Navigation Toolbar 12

2.2 The Study Dashboard 13

2.2.1 Study Overview 13

2.2.2 Results Overview 14

2.2.3 The Revisions Grid View 15

2.2.3.1 Adding a Revision 15

2.2.3.2 Updating a Revision – Checking and Approving 16

2.2.3.3 Deleting a Revision 16

2.2.4 The Recommendations Grid View 17

2.2.4.1 Adding a Recommendation 17

2.2.4.2 Updating a Recommendation 18

2.2.4.3 Deleting a Recommendation 19

2.3 The Bowtie Interface 19

2.3.1 The Study Data Tree View 19

2.3.2 The Main Workspace Window 20

2.3.2.1 Expanding, Collapsing, and Compacting Views 20

2.3.2.2 Adjusting the Zoom on the Main Workspace 21

2.3.2.3 Saving a Bowtie Diagram as an Image 21

2.3.3. Bowtie Interface Workspace Controls 21

2.3.3.1 Cause Workspace Controls 22

2.3.3.2 Safeguard Workspace Controls 22

2.3.3.3 Degradation Factor Workspace Controls 23

Table of Contents

2.3.3.4 Degradation Control Workspace Controls 24
2.3.3.5 Top Event Workspace Controls 25
2.3.3.6 Consequence Workspace Controls 25
2.4 The Causes Grid View 26
2.5 The Safeguards Grid View 26
2.6 The Consequences Grid View 27
2.7 The Cause Details Form 27
2.8 The Safeguard Details Form 30
2.9 The Degradation Factor Details Form 34
2.10 The Degradation Control Details Form 37
2.11 The Consequence Details Form 39
2.12 The Top Event Details Form 43
2.13 The Risk Criteria View 45
2.11.1 The Risk Criteria Side Toolbar 46
2.11.2 The Risk Criteria Main Controls 49
2.11.2.1 Saving Changes 49
2.11.2.2 Adding and Deleting Rows in the Table 49
2.11.2.3 Moving Rows Up and Down in the Table 50
2.11.2.4 Zooming In and Out 50
2.11.3 The Risk Matrix Page 51
2.11.4 The Likelihood Categories Page 52
2.11.5 The Consequence Categories Page 53
2.11.6 The Risk Rankings Page 54
2.14 Study Settings 56
2.15 Copying a Study 57
2.16 Deleting a Study 57
3.1 Mitigated Cause Frequency Calculations 59
3.2 Top Event Frequency Calculations 59

Table of Contents

3.3 Consequence Frequency Calculations 60
3.4 Meeting TMEL Criteria 61

Section 0 – Quick Reference

0.1 Definitions

The following terms are used regularly in Bowtie-Q™.

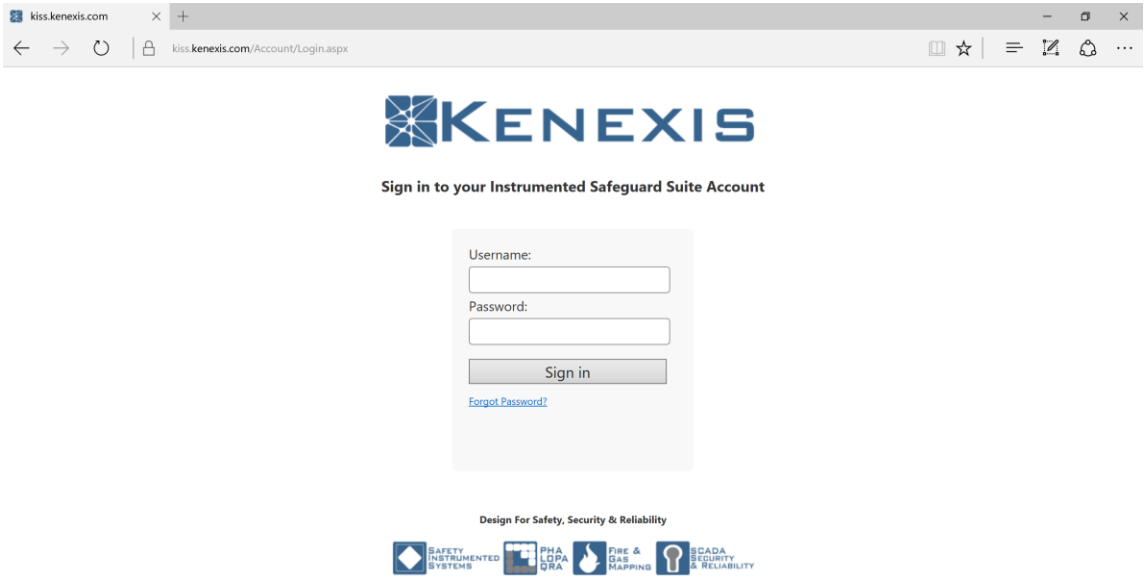
Term	Definition	Acronym
Layer of Protection Analysis	A semi-quantitative study that analyzes one incident scenario at a time to identify required risk reduction measures and to recommend layers of protection if needed.	LOPA
Target Mitigated Event Likelihood	The maximum tolerable risk (expressed as a frequency). Also known as target frequency.	TMEL
Independent Protection Layer	Safeguards that are specifically designed to prevent the hazard identified, independent from initiating events or other IPLs. IPLs provide at least one order of magnitude risk reduction, and are auditable (e.g. operator intervention, pressure relief, etc.).	IPL
Cause	An event, situation, or condition which results, directly or indirectly in an accident or incident. Causes may also be referred to as “Threats” or “Initiating Events.”	
Safeguard	Any device, system, or action that interrupts the chain of events following an initiating event (Preventative Safeguard) or that mitigates the consequences (Mitigative Safeguard). Safeguards may also be referred to as “Barriers” or “Independent Protection Layers (IPLs).”	
Consequence	The undesirable result of a loss event, usually measured in health and safety effects, environmental impacts, loss of property, and business interruption costs.	

For more information, visit https://www.aiche.org/ccps/resources/glossary.

Section 1 – Getting Started

1.1 Instructions for First Time Login

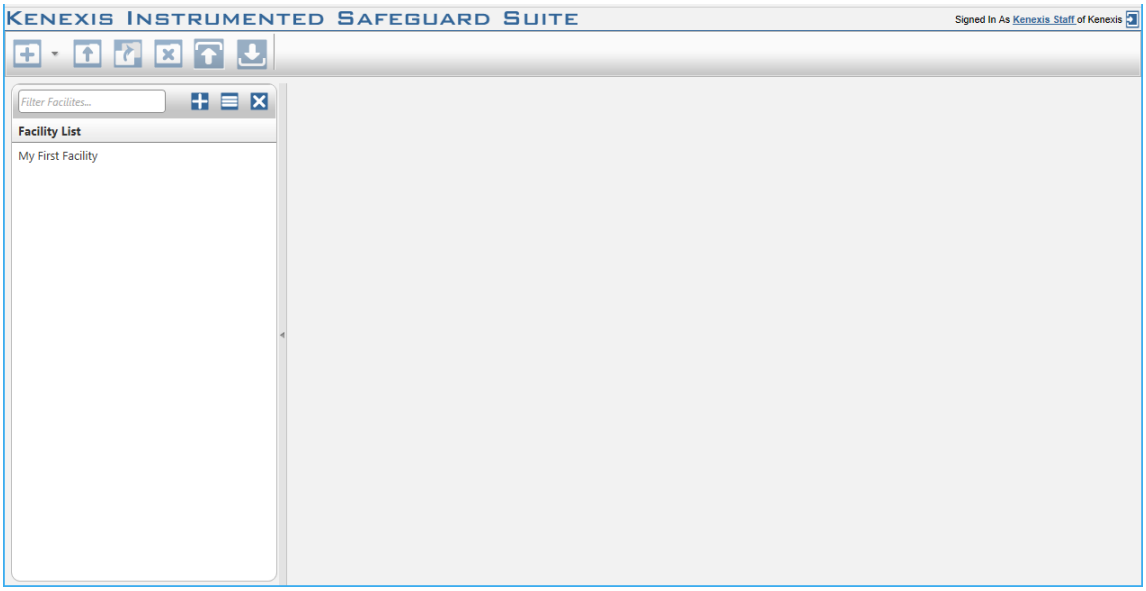
Welcome to Kenexis Integrated Safety Suite (KISS). If you are new to the Kenexis Integrated Safety Suite (KISS) you should have received a welcome package via email with your login credentials. Once you have received this package, it means that your account has been configured and is ready to use. You can access your account by directing your browser to https://kiss.kenexis.com. This will navigate your browser to the KISS login page, shown below:



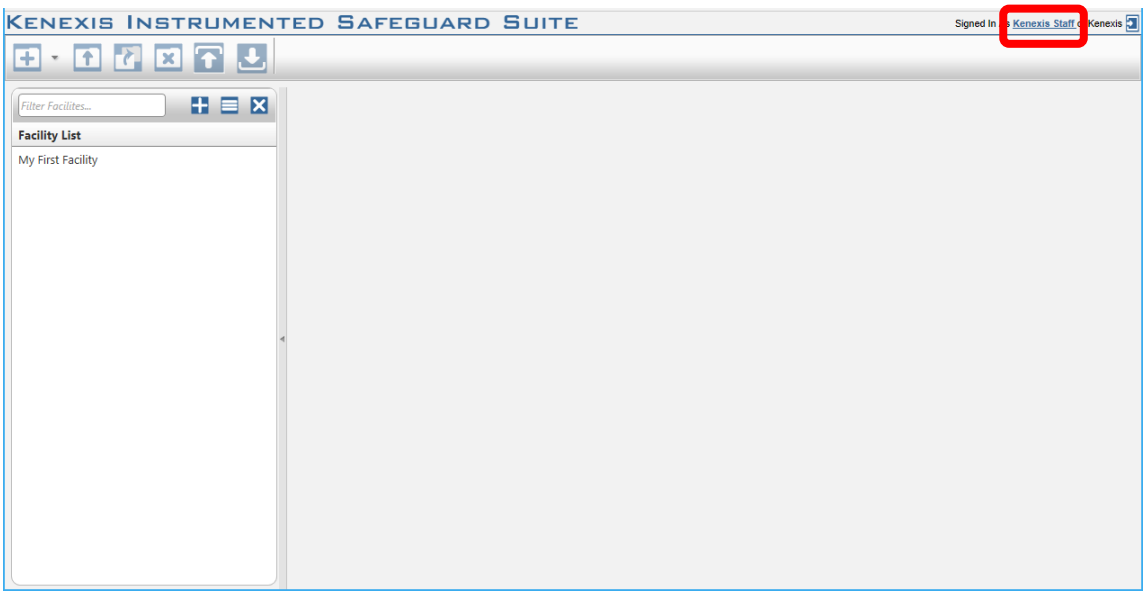
From here you can login using the login credentials provided in your KISS welcome email. If you've lost your temporary password, it can be restored by using the "Forgot Password?" link. If you've lost your username, please contact support@kenexis.com for assistance.

Section 1 – Getting Started

After Successful login, you should arrive at the Study Manager page, shown below:

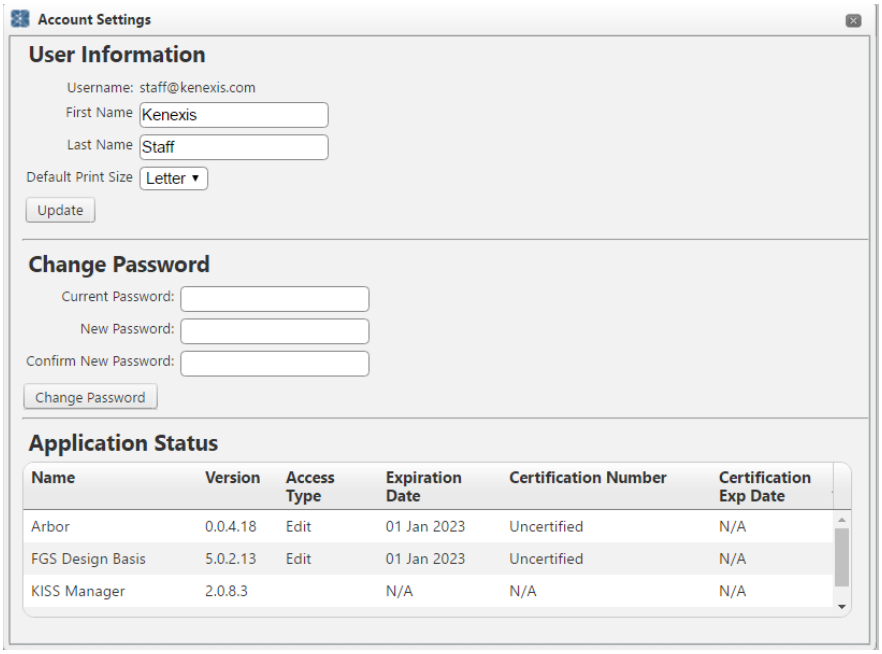


From here, it is highly recommended that you reset your temporary password. You can reset your password by clicking on your name in the top right corner.



This will open your account settings where you have the option to change your password.

Section 1 – Getting Started



1.2 Login Troubles

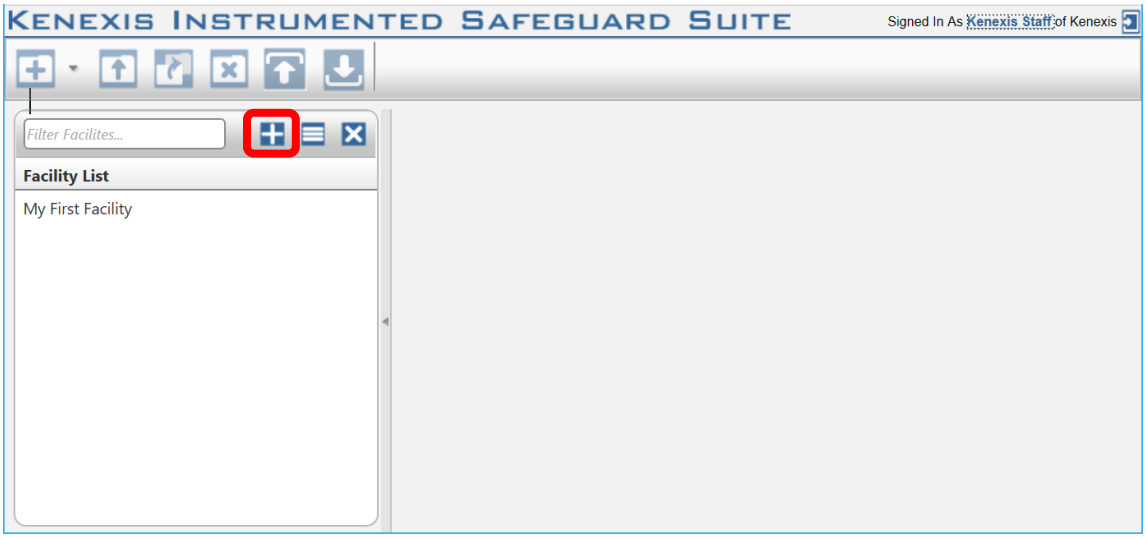
This section describes some of the common causes and solutions for trouble you may face when logging into the Kenexis Instrumented Safeguard Suite (KISS).

Problem #1: I forgot my password
Solution: Visit Kiss.Kenexis.com and click on the "Forgot Password?" link.

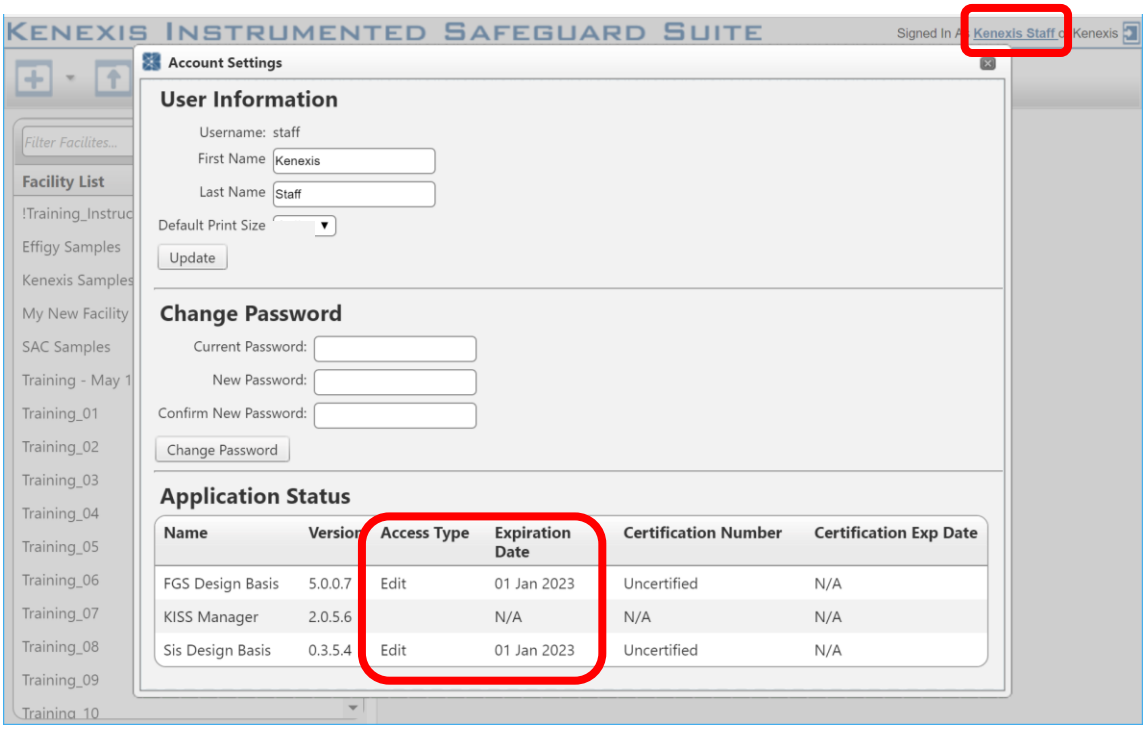
Problem #2: I forgot my username
Solution: Contact Support@Kenexis.com to restore your account

Problem #3: When I login I don't see any studies on the Study Manager Page
Solution: If you are not able to view any facilities or studies on the Study Manager page it is because you do not have access to any study information. Depending on your roles within your company you may have privileges to create a new facility by clicking on the Add Facility button (shown below).

Section 1 – Getting Started



If your account has been assigned read-only permissions, you will need to contact your project manager/company administrator to grant you access to the desired studies. You can view your account permissions on your account settings window, which is accessed by clicking on your name in the top right corner.



Section 1 – Getting Started

1.3 Other Resources

In addition to the information provided in this user's manual, help and support for use of the Bowtie-Q™ Analysis Software can also be obtained from the following resources:

- Online or Instructor Based Training Course - A full list of these available courses can be found at www.kenexis.com/training.
    - Bowtie Analysis – Theory and Fundamentals
    - Using Bowtie-Q™ (coming soon…)

- Books and other Kenexis publications relating to reliability engineering methodologies, including:
    - Books
        - Kenexis Safety Instrumented Systems Engineering Handbook
    - Papers and Magazine Articles
    - Kenexis Employee Blog Posts
- Live Support from Kenexis Staff. Support requests can be submitted to Kenexis staff via the Kenexis support system, which can be accessed from https://support.kenexis.com.

Section 2 – Interface

2.1 The Navigation Toolbar

The navigation toolbar serves as the primary means for navigating the Bowtie-Q™ study editor interface and appears on all pages in the editor. This section details the available buttons on the toolbar:

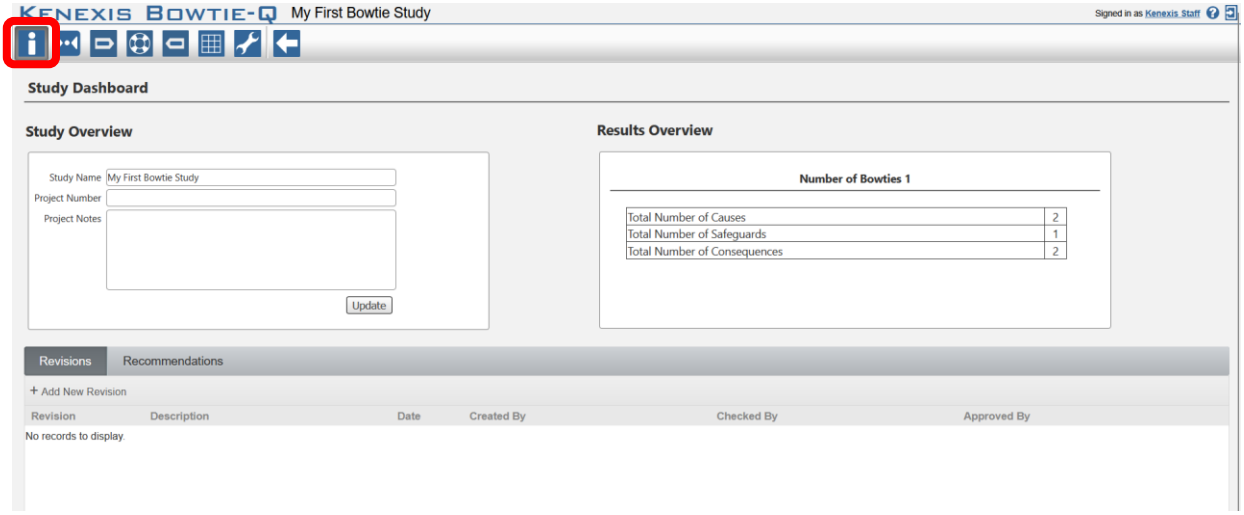
Button	Description
	The Overview button will navigate to the Study Dashboard page for the active study.
	The Bowtie button will navigate to the Bowtie view. From this view you can add, edit or delete objects and build relationships between causes, safeguards, top events, and consequences.
	The Causes page will display a list of all causes for the current bowtie diagram study. Causes are used to show the reason or reasons for the top event occurring.
	The Safeguards page will display a list of all safeguards in the current bowtie diagram study. Safeguards are used to represent the events, systems, or situations that prevent the top event from occurring or mitigate consequences if the top event does occur.
	The Consequences page will display a list of all consequences for the current bowtie diagram study. Consequences are used to show the results of the top event if safeguards fail.
	The Risk Criteria page will display the associated risk matrices and other risk tolerance criteria for the bowtie diagram study. Risk matrices provide a standard for numerical analysis of risk levels based on likelihoods and consequences.

Section 2 – Interface

Button	Description
	The Study Settings button will allow you to change overall and individual aspects of the bowtie diagram study.
	The Back to Study List button will navigate to the Study Manager page.

2.2 The Study Dashboard

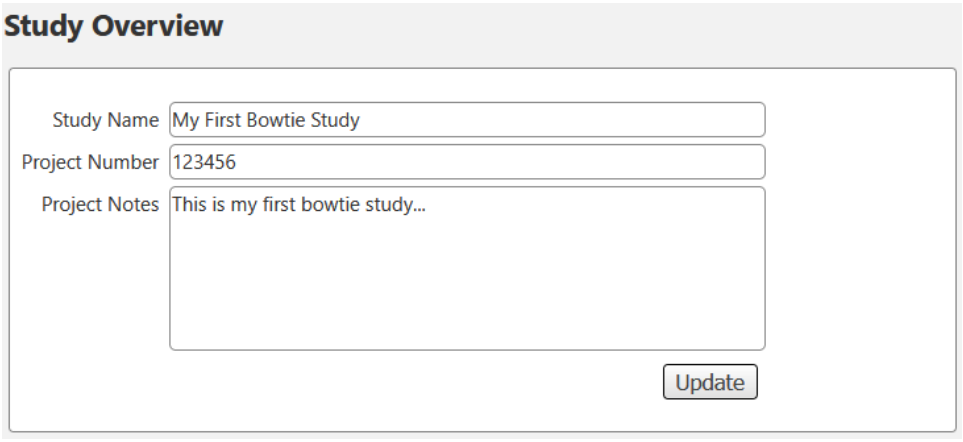
The Study Dashboard provides a high-level overview of a Bowtie study in Bowtie-Q™. The Study Dashboard has three sections, the Study Overview, the Results Overview, and the Revisions & Recommendations Grid Views. The study dashboard can be reached by clicking on the Overview icon in the Navigation Toolbar.



2.2.1 Study Overview

The Study Overview is used to input administrative information about a bowtie study. None of the fields in the study overview section affect the calculated results of the bowtie diagram, as these fields are provided for information tracking only. The following fields can be input in the study overview:

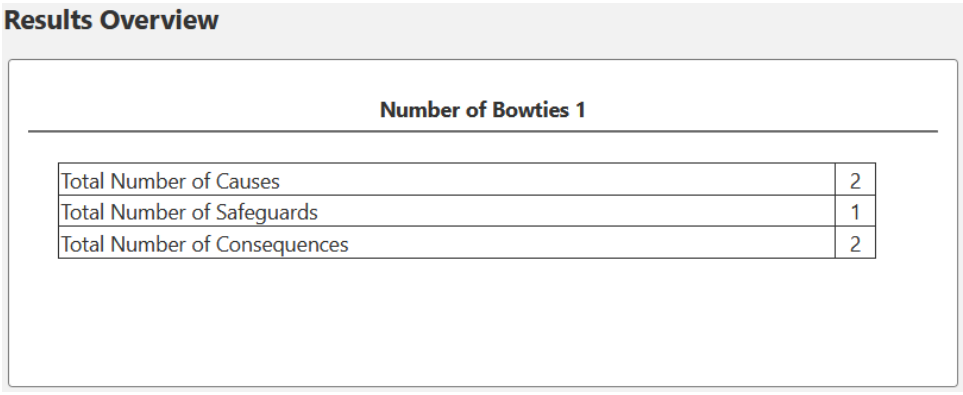
Section 2 – Interface



- Study Name: Study Name is a required field and is set when a study is created. The Study Name can be updated at any time from the Study Overview on the Study Dashboard. The Study Name will be displayed on the Study List page of the KISS Manager application.
- Project Number: This field is provided to track a project number for project management purposes.
- Project Notes: Any notes specific to a study can be entered here.

2.2.2 Results Overview

The results overview section of the Study Dashboard provides a summary of the results of a study at a glance. The results overview includes the number of bowties in the study, and the total number of causes, safeguards, and consequences included in the analysis.



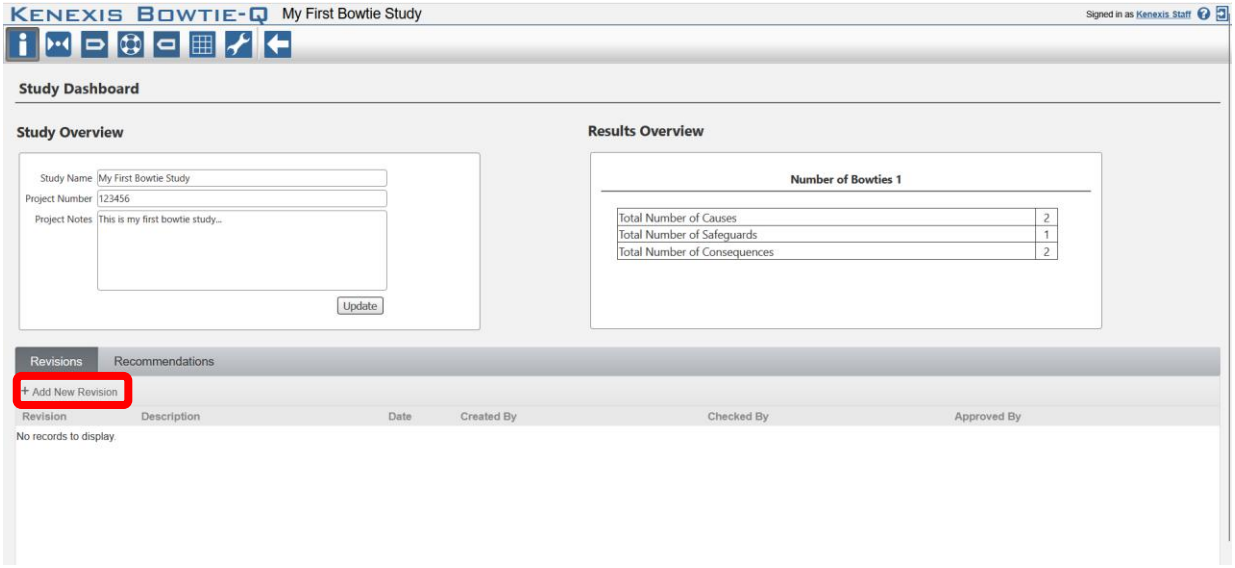
Section 2 – Interface

2.2.3 The Revisions Grid View

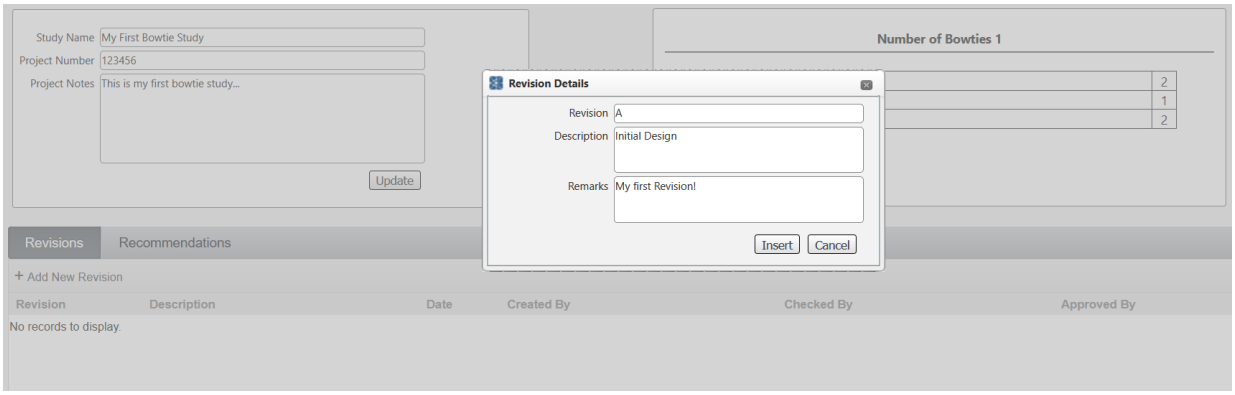
The revisions grid view is used to add, edit and delete revisions. Each Bowtie-Q™ study can have one or more revisions linked to the study. Revisions are useful for tracking changes to the bowtie analysis model and documenting the personnel response for making those changes, as well as the parties responsible for checking and approving the work.

2.2.3.1 Adding a Revision

A revision can be added to a Bowtie study by clicking on the Add New Revision button in the header of the revisions grid view as shown below:



Adding a revision will open the Revision Details window where a revision number, description and remarks can be added.



Section 2 – Interface

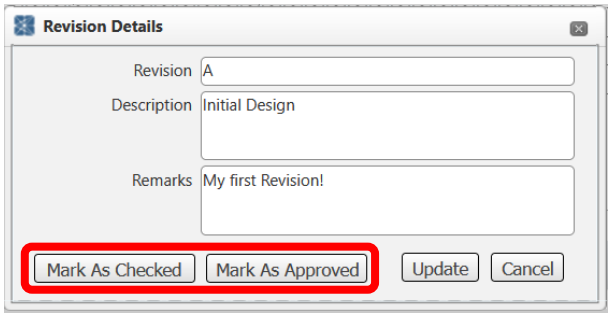
Clicking Insert in the Revision Details window will add the revision to the revisions grid. When a revision is added, the revision date will automatically be populated, as will the "created by" field in the revisions grid view. The "created by" field will be populated with the name of the user who inserted the revision.

2.2.3.2 Updating a Revision – Checking and Approving

Existing revisions can be updated by either clicking on the revision number or double-clicking on a row in the revision grid view.

Updating a revision will open the revision details window in update mode. When the revision details window is opened in update mode two additional buttons will appear.

- Mark As Checked
- Mark As Approved



These two additional buttons can be used to check and/or approve revisions. As with the creation of revisions, the names of the checker and approver will be automatically populated based on the name of the user who clicks the checked / approved button. After a revision has been checked or approved, the name of the user(s) will appear in the revisions grid view. Once you have modified the desired details, hit the Update button to apply your changes, or the Cancel button to leave the revision details form.

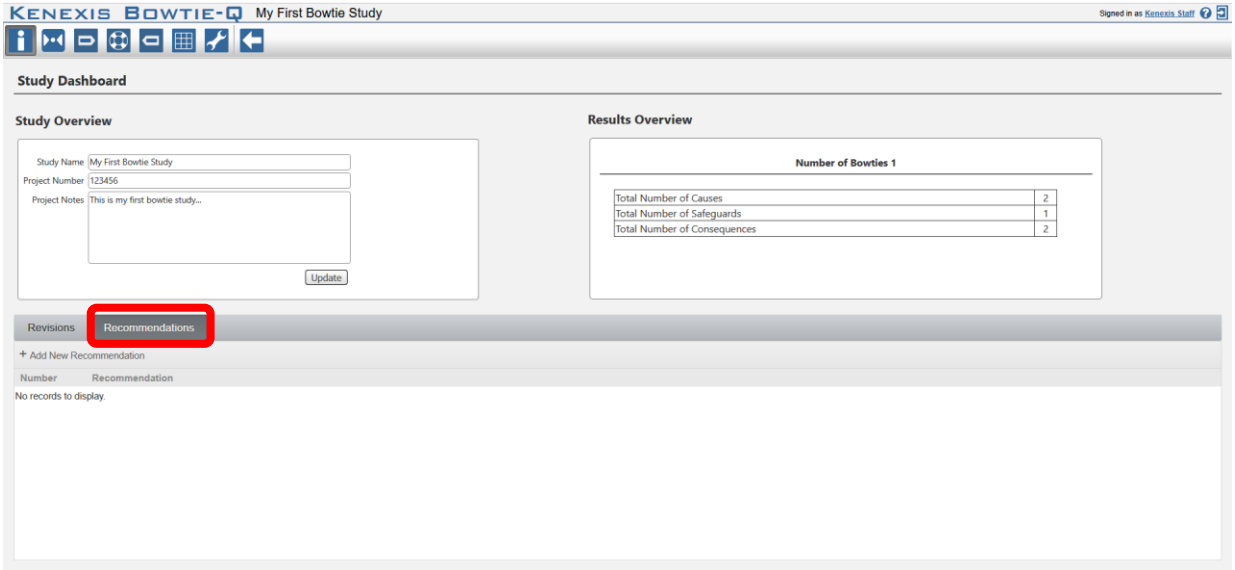
2.2.3.3 Deleting a Revision

Revisions can be deleted by clicking on the delete icon (red x) at the far-right side of the revisions grid view.

Section 2 – Interface

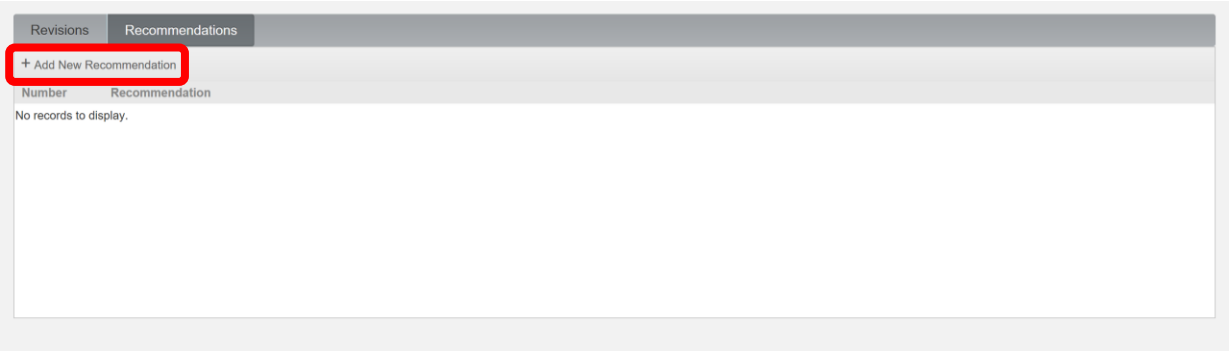
2.2.4 The Recommendations Grid View

The recommendations grid view is used to add, edit and delete recommendations. Each Arbor study can have one or more recommendations linked to the study. Revisions are useful for documenting proposed changes to a system design based on the result of bowtie analysis modeling. The recommendations grid view can be shown by clicking on the recommendations tab on the study dashboard.



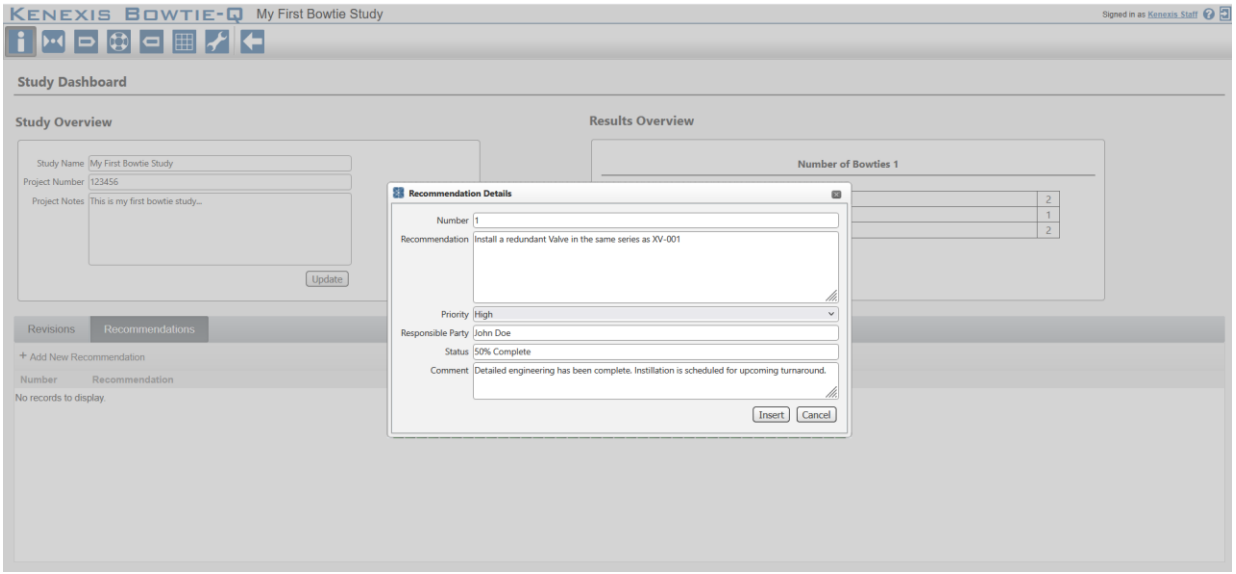
2.2.4.1 Adding a Recommendation

A recommendation can be added to a Bowtie study by clicking on the Add New Recommendation button in the header of the recommendations grid view as shown below:



Adding a recommendation will open the Recommendation Details window where the following information about a recommendation can be entered.

- **Recommendation Number:** A unique identifier used for recommendation tracking. By default, the recommendation number will automatically enumerate to the first integer value greater than zero which is not currently being used in the list of recommendations for a study.
- **Recommendation**: Details of the recommended actions.
- **Priority**: Priority of the recommendation relative to other recommendations. Typically, high priority recommendations will require a quicker response than low priority recommendations.
- **Responsible Party**: The person, organization or department responsible for addressing the recommendation actions.
- **Status**: The status of implementation of the recommendation.
- **Comments**: Any additional comments regarding the recommendation.



Clicking Insert in the Recommendation Details window will add the recommendation to the recommendations grid.

2.2.4.2 Updating a Recommendation

Existing Recommendations can be updated by either clicking on the recommendation number or double-clicking on a row in the recommendations grid view.

Section 2 – Interface

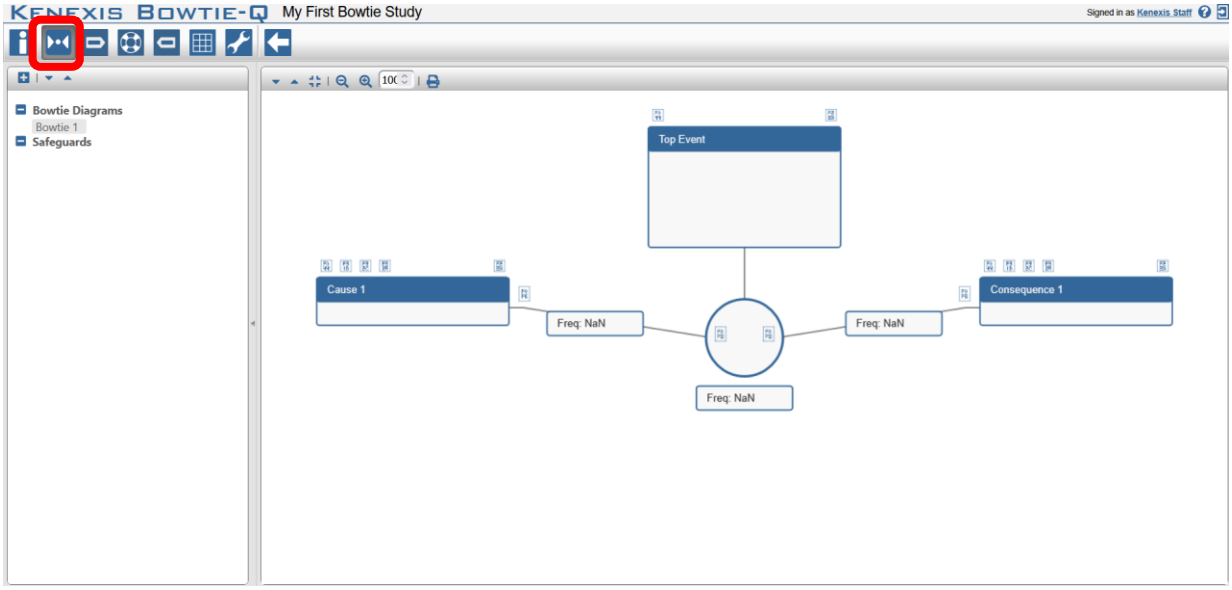
Updating a recommendation will open the Recommendation Details window in update mode.

2.2.4.3 Deleting a Recommendation

Recommendations can be deleted by clicking on the delete icon (red x) at the far-right side of the recommendations grid view.

2.3 The Bowtie Interface

The Bowtie Interface is the primary interface for Bowtie-Q™. This page is where most data entry takes place and is the interface where you will spend most of your time when constructing a bowtie model. The Bowtie Interface can be reached by clicking on the Bowtie icon in the Navigation Toolbar (highlighted below).

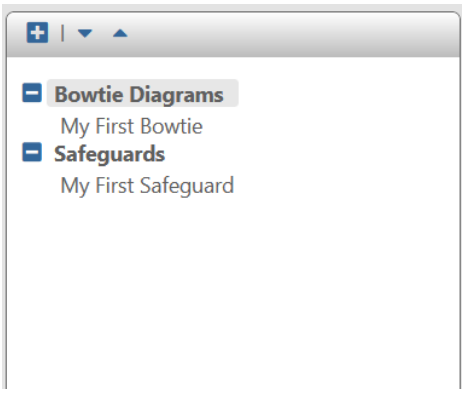


2.3.1 The Study Data Tree View

To the left of the interface is the Study Data Tree View. In this view you can see all bowtie diagrams and their associated safeguards included in the current study. This allows for easy navigation between different bowtie diagrams by double-clicking on the bowtie diagram you wish to view.

Section 2 – Interface

In addition, double-clicking on a safeguard in the tree view will display its properties in a dialog window.



The three buttons at the top are the New Bowtie button, the Expand All button, and the Collapse All button respectively. New Bowtie creates a new diagram, which can make use of new or existing safeguards. Expand All and Collapse All allow you to see all Bowtie diagrams and all safeguards, or hide them, all within the Study Data Tree View.

2.3.2 The Main Workspace Window

The Main Workspace Window displays the Bowtie diagram. There is a collection of controls at the top of the workspace for interacting with the diagram. These controls are shown below:

2.3.2.1 Expanding, Collapsing, and Compacting Views

The three controls to the left of the panel allow you to expand, collapse, and toggle compact view for better viewing of the diagram.

The Expand button allows you to see the full details of causes, safeguards, and consequences. For causes, this includes cause type, instrument tags, and frequencies. For safeguards, this includes safeguard type, instrument tags, safety integrity levels (SILs), the probability of safeguard failure, whether the safeguard is a PHA safeguard, and whether the safeguard is creditable as an independent protection layer (IPL) in layer of protection analysis (LOPA). For consequences, this includes the severity categories, and their associated Target Mitigated Event Likelihood (TMEL) frequencies with an indicator as to whether they have been met (green) or not (red).

The Collapse button allows you to hide these details.

The Toggle Compact View button compacts or uncompacts the bowtie diagram. A compacted view hides most information, including frequency data.

Section 2 – Interface

2.3.2.2 Adjusting the Zoom on the Main Workspace

The zoom of the main workspace can be adjusted using the zoom controls in the main workspace header menu shown below:

By default, the zoom of the main workspace is always reset on 100% when the diagram is loaded. Clicking the minus magnifying glass will zoom out 5%. Clicking the plus magnifying glass will zoom in 5%. The current zoom setting is displayed in the text box to the right of the magnifying glasses. In the above image the diagram displays 100% zoom, which is the default setting. The zoom can be adjusted manually by simply selecting the text in box and entering the desired zoom setting.

2.3.2.3 Saving a Bowtie Diagram as an Image

The current bowtie diagram can be saved as an image using the print button. Clicking the print button will download an image file containing the bowtie diagram in *.png format.

The image can be saved in expanded, collapsed, or toggled view, which can be changed using the leftmost three buttons.

2.3.3. Bowtie Interface Workspace Controls

Within the bowtie interface, each cause, safeguard, degradation factor, degradation control, top event, and consequence have workspace controls that allow you to interact with them. By default, the bowtie interface includes one cause, one top event, and one consequence. Additional causes and consequences can be added by using the Top Event Workspace Controls (Section 2.3.3.5). Preventative Safeguards can be added after a cause by using the Cause Workspace Controls (Section 2.3.3.1). Mitigative Safeguards can be added before a consequence by using the Consequence Workspace Controls (Section 2.3.3.6). Degradation factors can be added using the Safeguard Workspace Controls (Section 2.3.3.2). Degradation controls can be added using the Degradation Factor Workspace Controls (Section 2.3.3.3).

Section 2 – Interface

2.3.3.1 Cause Workspace Controls

From left to right, each cause has workspace controls that allow you to perform the following actions:

- Edit the Cause Details Form (See Section 2.7)
- Expand or Collapse the full details of the cause. This includes cause type, instrument tags, and frequencies.
- Move the cause up if there are multiple causes and the cause is below another.
- Move the cause down if there are multiple causes and the cause is above another.
- Delete the cause. You cannot delete the cause if there is only one cause for the top event.
- Add a new preventative safeguard to the right of the cause and any existing safeguards, before the top event.

2.3.3.2 Safeguard Workspace Controls

From left to right, each safeguard has workspace controls that allow you to perform the following actions:

- Edit the Safeguard Details Form (See Section 2.8)
- Expand or Collapse the full details of the safeguard. This includes safeguard type, instrument tags, safety integrity levels (SILs), the probability of safeguard failure, whether the safeguard is a PHA safeguard, and whether the safeguard is creditable as an independent protection layer (IPL) in layer of protection analysis (LOPA).
- Move the safeguard left if there are multiple safeguards and the safeguard is to the right of another.

- Move the safeguard right if there are multiple safeguards and the safeguard is to the left of another.
- Add a new degradation factor associated with the safeguard.
- Delete the safeguard.

If you choose to add a degradation factor to your safeguard, the safeguard controls will change slightly to accommodate for this.

The top control highlighted in red allows you to expand and collapse your view of the degradation factors associated with the safeguard. The bottom control allows you to add additional degradation factors.

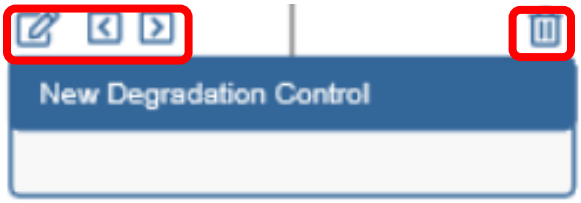
2.3.3.3 Degradation Factor Workspace Controls

From left to right, each degradation factor has workspace controls that allow you to perform the following actions:

- Edit the Degradation Factor Details Form (See Section 2.9)
- Move the degradation factor up if there are multiple degradation factors and the degradation factor is below another.
- Move the degradation factor down if there are multiple degradation factors and the degradation factor is above another.
- Delete the degradation factor.
- Add a new degradation control associated with the degradation factor.

Section 2 – Interface

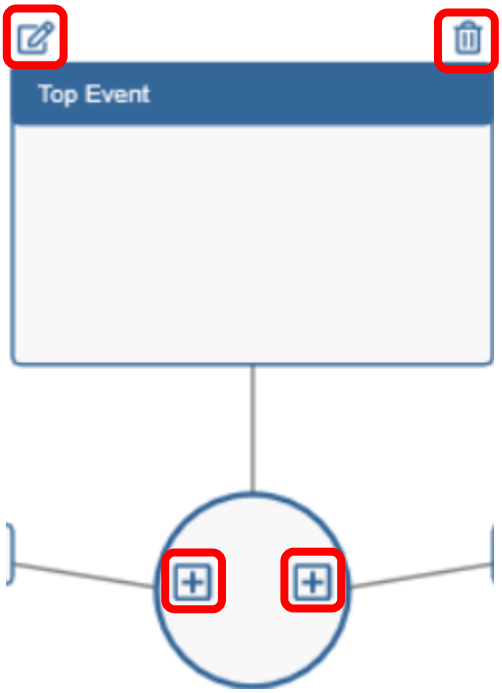
2.3.3.4 Degradation Control Workspace Controls



From left to right, each degradation control has workspace controls that allow you to perform the following actions:

- Edit the Degradation Control Details Form (See Section 2.10)
- Move the degradation control left if there are multiple degradation controls and the degradation control is to the right of another.
- Move the safeguard right if there are multiple degradation controls and the degradation control is to the left of another.
- Delete the degradation control.

2.3.3.5 Top Event Workspace Controls



From left to right, the top two controls for the top event allow you to perform the following actions:

- Edit the Top Event Details Form (See Section 2.12)
- Delete the top event. NOTE: This deletes the entire bowtie diagram.

From left to right, the bottom two controls for the top event allow you to perform the following actions:

- Add a new cause below any existing causes.
- Add a new consequence below any existing consequences.

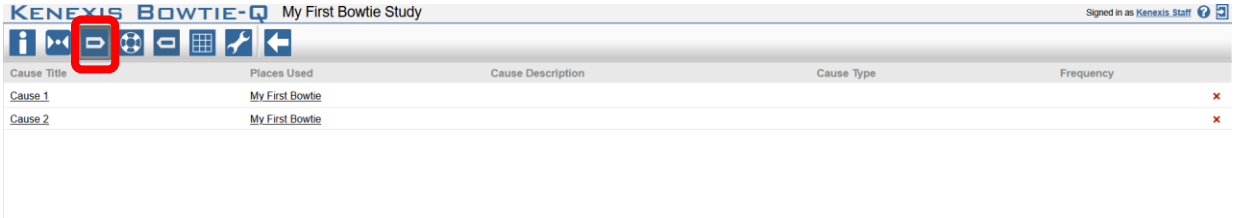
2.3.3.6 Consequence Workspace Controls

From left to right, each consequence has workspace controls that allow you to perform the following actions:

- Add a new mitigative safeguard to the left of the consequence and any existing safeguards, after the top event.
- Edit the Consequence Details Form (See Section 2.11)
- Expand or Collapse the full details of the consequence. This includes the severity categories, and their associated Target Mitigated Event Likelihood (TMEL) frequencies with an indicator as to whether they have been met (green) or not (red).
- Move the consequence up if there are multiple consequences and the consequence is below another.
- Move the consequence down if there are multiple consequences and the consequence is above another.
- Delete the consequence. You cannot delete the consequence if there is only one consequence for the top event.

2.4 The Causes Grid View

The Causes Grid View displays all causes in the current study, including causes from all individual bowtie diagrams. The Causes Grid View can be reached by clicking on the Causes icon in the navigation toolbar.

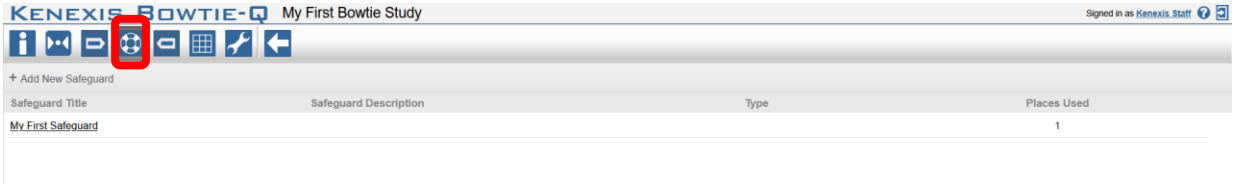


From the Causes Grid View, the properties of a cause can be displayed by either double-clicking on a row of the grid or clicking on the cause title. Each cause and all references to the cause can be deleted by pressing the red X icon on the far-right. A warning window will pop up to confirm your deletion.

2.5 The Safeguards Grid View

The Safeguards Grid View displays all safeguards in the current study, including safeguards from all individual bowtie diagrams. The Safeguards Grid View can be reached by clicking on the Safeguards icon in the navigation toolbar.

Section 2 – Interface



Within the Safeguards Grid View, you can add new safeguards using the Add New Safeguard button. This will bring up a dialog window where the properties of the safeguard can be modified. From the Safeguard Grid View, the properties of a safeguard can be displayed by either double-clicking on a row of the grid or clicking on the safeguard title. Each unused safeguard and all references to the safeguard can be deleted by pressing the red X icon on the far-right. A warning window will pop up to confirm your deletion.

2.6 The Consequences Grid View

The Consequences grid view displays all consequences in the current study, including consequences from all individual bowtie diagrams. The Consequences Grid View can be reached by clicking on the Consequences icon in the navigation toolbar.

From the Consequences Grid View, the properties of a consequence can be displayed by either double-clicking on a row of the grid or clicking on the consequence title. Each consequence and all references to the consequence can be deleted by pressing the red X icon on the far-right. A warning window will pop up to confirm your deletion.

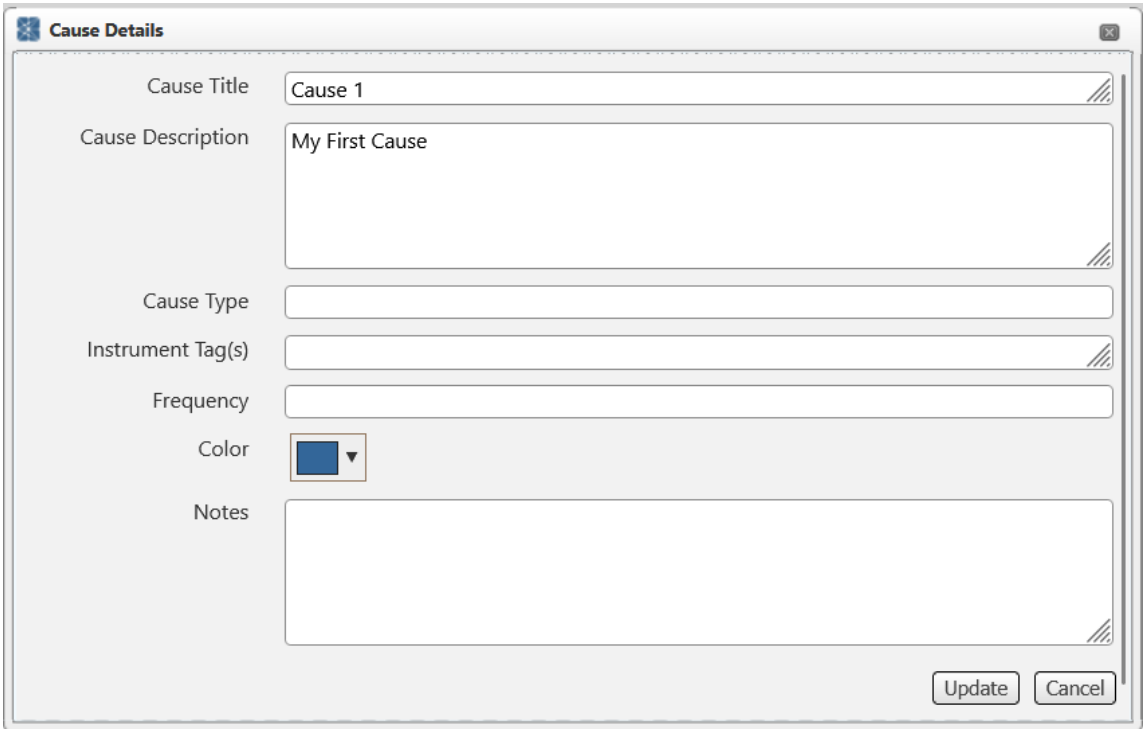
2.7 The Cause Details Form

The Cause Details Form is a window for entering information about the properties of a cause. There are several ways to reach the Cause Details Form, including:

- From the Bowtie Interface
  - double-click on the desired cause within the bowtie diagram
  - double-click on the Edit button for the desired cause
- From the Cause Grid View
  - double-click on a row of the grid
  - click on the title of a cause

Section 2 – Interface

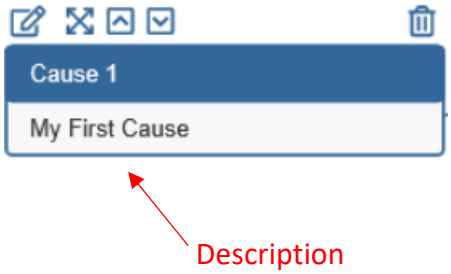
The Cause Details Form is shown below:

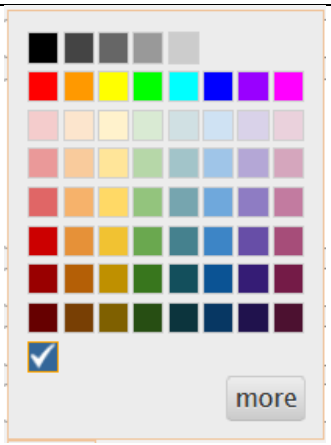
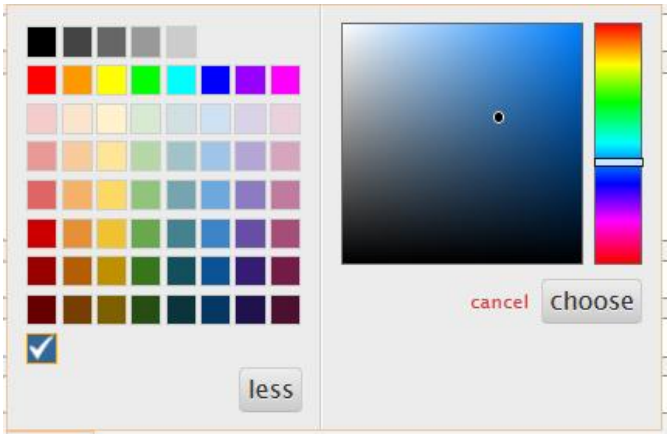


The following properties for a cause can be set from the Cause Details Form:

Cause Title	The title of the cause. The cause title is displayed in the top section of the cause details on the bowtie model.  When a new cause is created the cause title is set by default. The default title for a cause is “Cause #”, where # is an automatically enumerated integer value. When a cause is created, the integer will be set to the lowest integer value greater than zero which has not already been used in the study. It is highly recommended that cause titles be unique, however this is not a requirement.

Section 2 – Interface

Cause Description	The description of the cause. The cause description is displayed in the lower section of the cause details on the bowtie model. The cause description is generally used to give any background information related to the cause. 
Cause Type	The cause type is used to document the category of cause, e.g. BCPS malfunction, operator error, etc.
Instrument Tag(s)	The instrument tags field allows you to document tag numbers for instrumentation associated with the cause.
Frequency	The frequency of the cause occurring. Used in calculations. Within Bowtie-Q™, there are no defined units. It is up to the user to choose a time unit (customarily 1/years) for their calculations and ensure all time units are consistent.
Color	The color of the cause, as it appears on the bowtie diagram. The color defaults to Kenexis Blue but can be changed to any number of preprogrammed colors, or to the color of your choosing using a selection interface. This interface can be accessed using the More button and closed with the Less button.

	  Once you have your desired color, hit the Choose button to lock it in. If you wish to close the color interface, you can hit the Cancel button.
Notes	Any other notes or comments relating to the cause.

Once you have modified the desired details, hit the Update button to apply your changes, or hit the Cancel button to leave the Cause Details Form.

2.8 The Safeguard Details Form

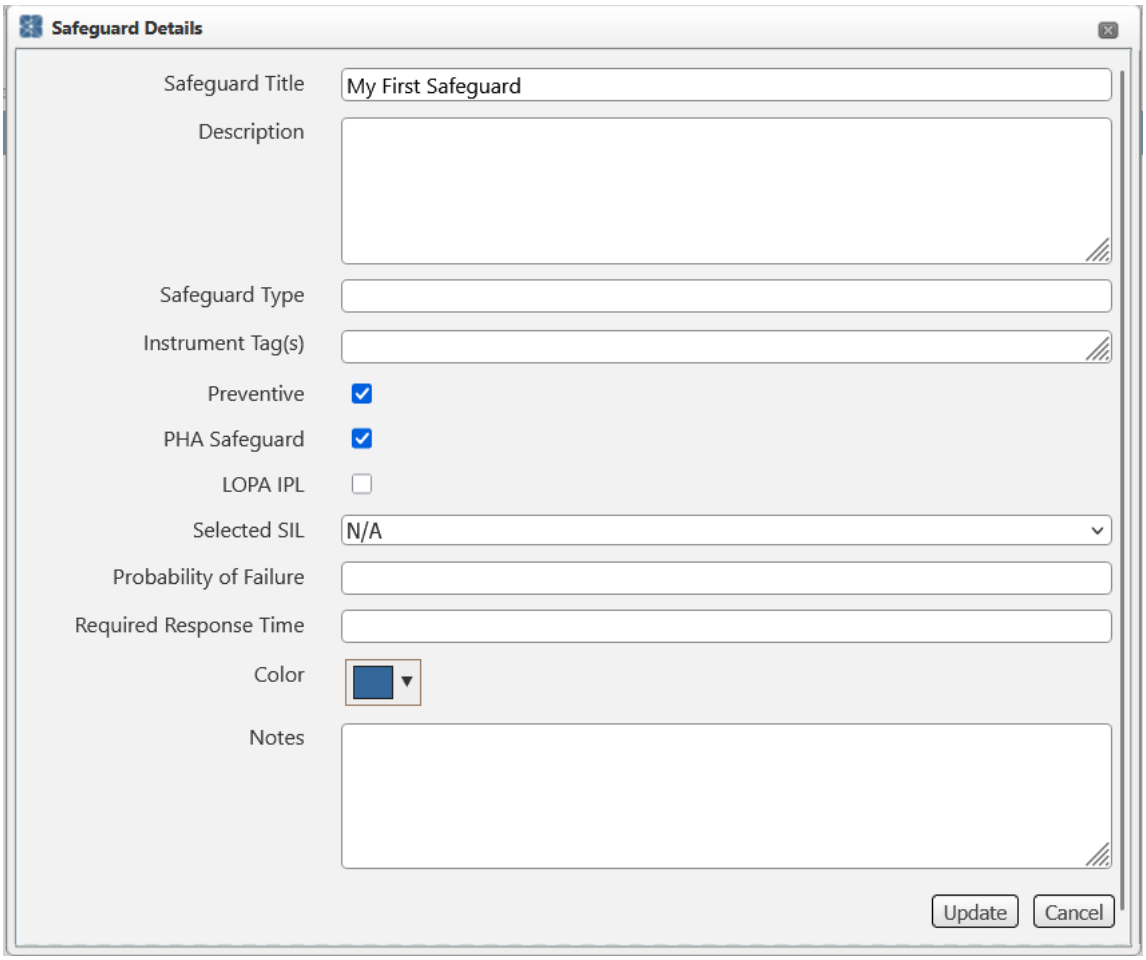
The safeguard details form is a window for entering information about the properties of a safeguard. There are several ways to reach the safeguard details form, including:

- From the Bowtie Interface
  - double-click on the desired safeguard within the bowtie diagram
  - double-click on the Edit button for the desired safeguard

Section 2 – Interface

- From the Study Tree Data Tree
  - double-click on a safeguard title in the study tree view on the left side of the page
  - while in select mode, double-click on a safeguard in the main workspace (bowtie view)
- From the Safeguard Grid View
  - double-click on a row of the grid
  - click on the title of a safeguard

The Safeguard Details Form is shown below:



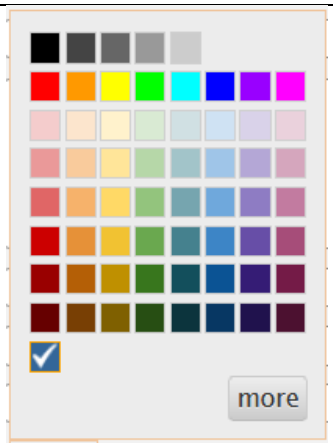
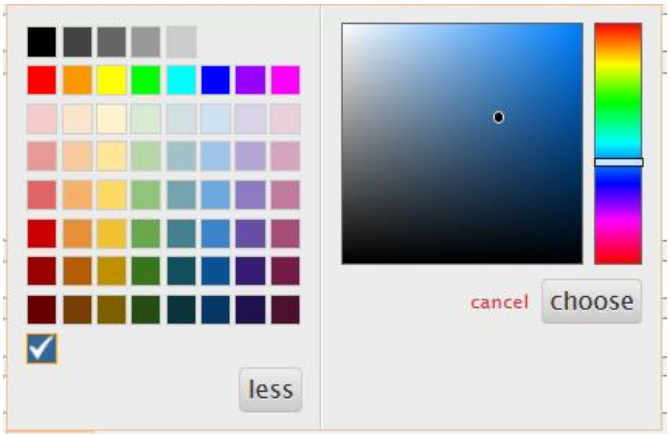
The following properties for a safeguard can be set from the Safeguard Details Form:

Section 2 – Interface

Title	The title of the safeguard. The safeguard title is displayed in the top section of the safeguard details on the bowtie model.  When a new safeguard is created, the safeguard title is set by default. The default title for a safeguard is “Safeguard #”, where # is an automatically enumerated integer value. When a safeguard is created, the integer will be set to the lowest integer value greater than zero which has not already been used in the study. It is highly recommended that safeguard titles be unique, however this is not a requirement.
Description	The description of the safeguard. The safeguard description is displayed in the lower section of the safeguard details on the bowtie model.  The safeguard description is generally used to give any background information related to the safeguard.
Safeguard Type	The safeguard type is used to document the category of safeguard, e.g. PSV, SIS, operator response, etc.
Instrument Tag(s)	The instrument tags field allows you to document tag numbers for instrumentation associated with the safeguard.
Preventative	The check box that describes whether the safeguard is preventative.
PHA Safeguard	The check box that describes whether the safeguard is a PHA safeguard.

Section 2 – Interface

LOPA IPL	The check box that describes whether the safeguard is creditable as an independent protection layer (IPL) in layer of protection analysis (LOPA).
Selected SIL	The selected SIL is safety integrity level for the safeguard as defined by IEC 61508 and IEC 61511. Within the Safeguard Details form, you can choose the selected SIL from the dropdown menu, as shown below: 
Probability of Failure	The probability (between 0 and 1) that the safeguard is in a failed state during a demand. Used in calculations.
Required Response Time	The maximum allowable time for the safeguard to respond to a demand. Within Bowtie-Q™, there are no defined units. It is up to the user to choose a time unit (customarily 1/years) for their calculations and ensure all time units are consistent.
Color	The color of the safeguard, as it appears on the bowtie diagram. The color defaults to Kenexis Blue but can be changed to any number of preprogrammed colors, or to the color of your choosing using a selection interface. This interface can be accessed using the More button and closed with the Less button.

	  Once you have your desired color, hit the Choose button to lock it in. If you wish to close the color interface, you can hit the Cancel button.
Notes	Any other notes or comments relating to the safeguard.

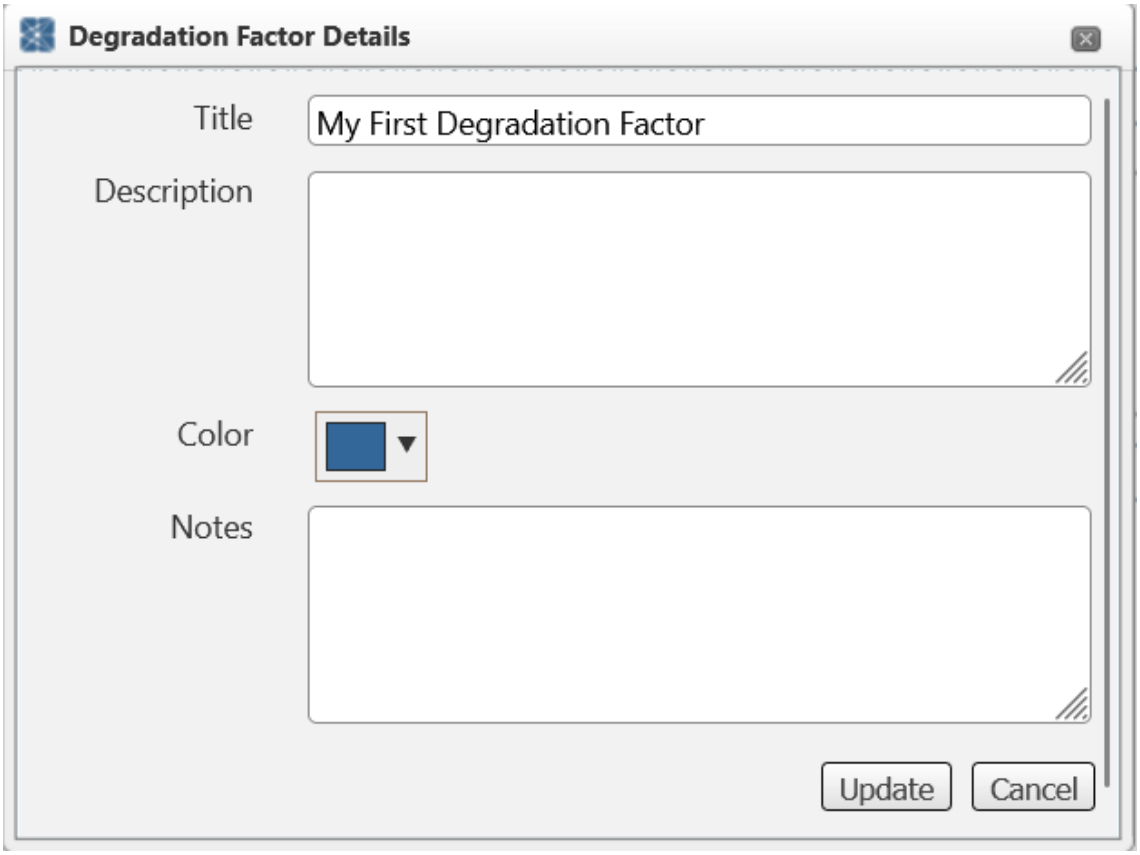
Once you have modified the desired details, hit the Update button to apply your changes, or hit the Cancel button to leave the Safeguard Details Form.

2.9 The Degradation Factor Details Form

The Degradation Factor Details Form is a window for entering information about the properties of a degradation factor. You can access the Degradation Factor Details Form from the Bowtie Interface by double-clicking on the desired degradation factor within the bowtie diagram, or by double-clicking on the Edit button for the desired degradation factor.

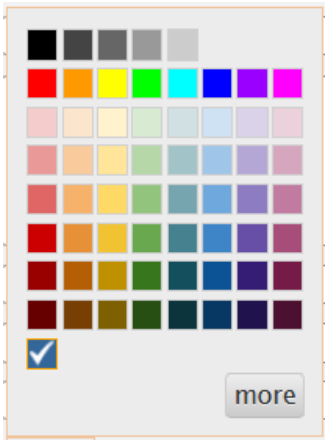
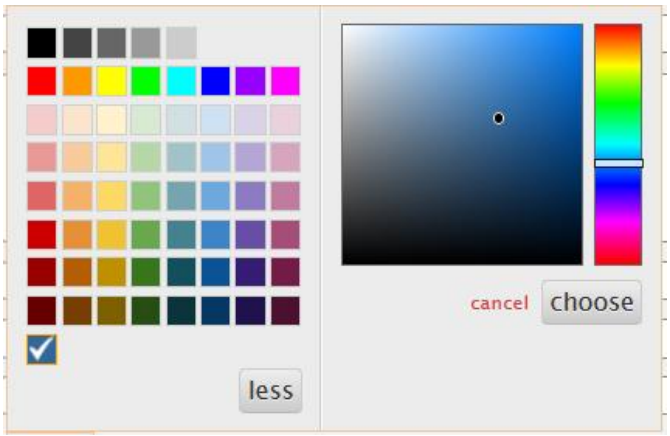
The Degradation Factor Details Form is shown below:

Section 2 – Interface



Title	The title of the degradation factor. The degradation factor title is displayed in the top section of the degradation factor details on the bowtie model. 

Section 2 – Interface

Description	The description of the degradation factor. The degradation factor description is displayed in the lower section of the degradation factor details on the bowtie model. The degradation factor description is used to give any background information on what is degrading the safeguard in question. 
Color	The color of the degradation factor, as it appears on the bowtie diagram. The color defaults to Kenexis Blue but can be changed to any number of preprogrammed colors, or to the color of your choosing using a selection interface. This interface can be accessed using the More button and closed with the Less button.  

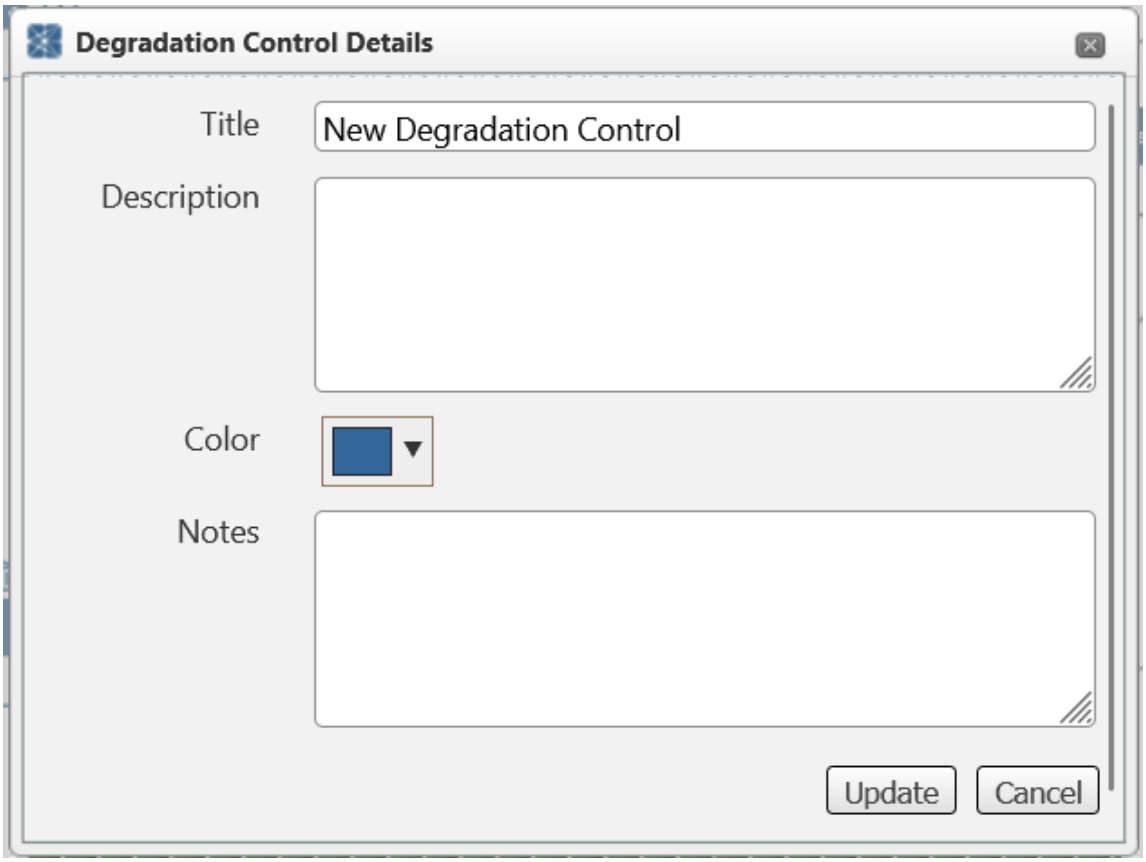
	Once you have your desired color, hit the Choose button to lock it in. If you wish to close the color interface, you can hit the Cancel button.
Notes	Any other notes or comments relating to the degradation factor.

Once you have modified the desired details, hit the Update button to apply your changes, or hit the Cancel button to leave the Degradation Factor Details Form.

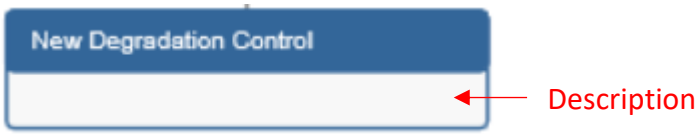
2.10 The Degradation Control Details Form

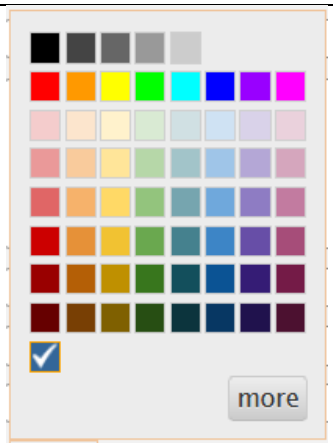
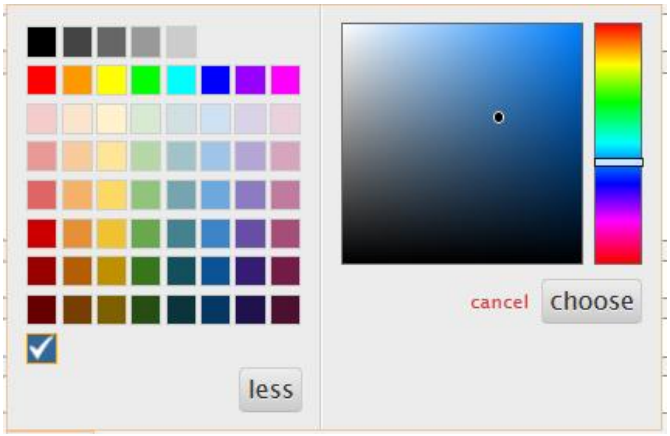
The Degradation Control Details Form is a window for entering information about the properties of a degradation control. You can access the Degradation Control Details Form from the Bowtie Interface by double-clicking on the desired degradation control within the bowtie diagram, or by double-clicking on the Edit button for the desired degradation control.

The Degradation Control Details Form is shown below:



Section 2 – Interface

Title	The title of the degradation control. The degradation control title is displayed in the top section of the degradation control details on the bowtie model. 
Description	The description of the degradation control. The degradation control description is displayed in the lower section of the degradation control details on the bowtie model. The degradation control description is used to give any background information on any controls that indicate whether a degradation factor is present for the safeguard in question and how it controls the degradation of the safeguard. 
Color	The color of the degradation control, as it appears on the bowtie diagram. The color defaults to Kenexis Blue but can be changed to any number of preprogrammed colors, or to the color of your choosing using a selection interface. This interface can be accessed using the More button and closed with the Less button.

	  Once you have your desired color, hit the Choose button to lock it in. If you wish to close the color interface, you can hit the Cancel button.
Notes	Any other notes or comments relating to the degradation control.

Once you have modified the desired details, hit the Update button to apply your changes, or hit the Cancel button to leave the Degradation Control Details Form.

2.11 The Consequence Details Form

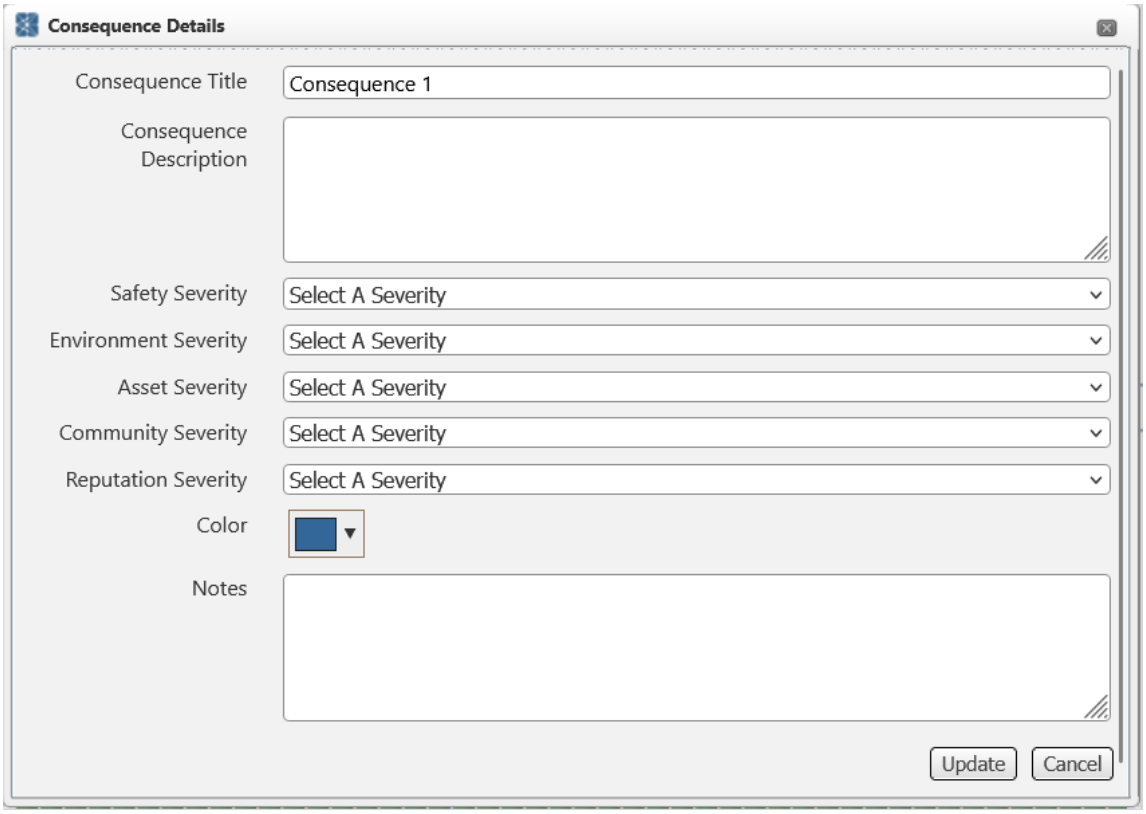
The Consequence Details Form is a window for entering information about the properties of a consequence. There are several ways to reach the Consequence Details Form, including:

- From the Bowtie Interface
  - double-click on the desired consequence within the bowtie diagram
  - double-click on the Edit button for the desired consequence

Section 2 – Interface

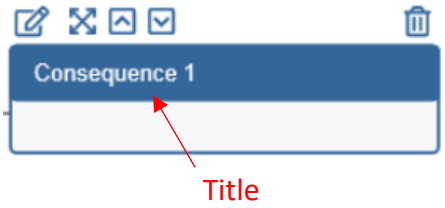
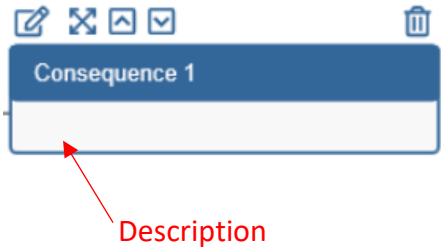
- From the Consequences Grid View
  - double-click on a row of the grid
  - click on the title of a consequence

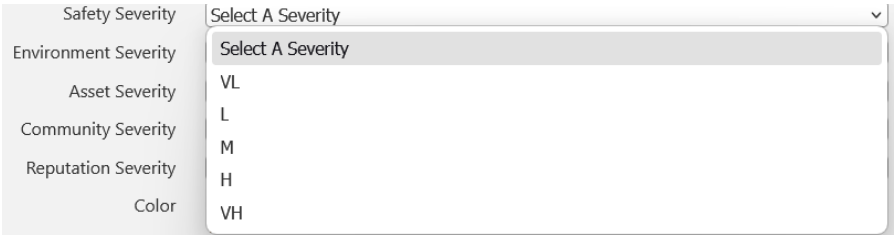
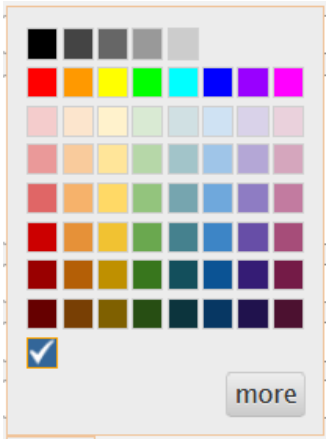
The Consequence Details Form is shown below:

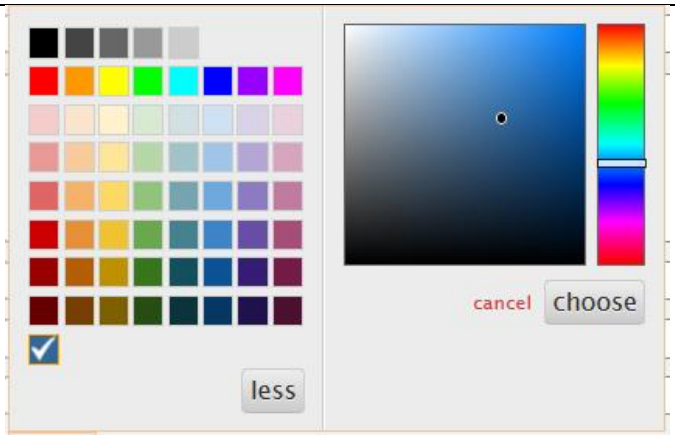


The following properties for a consequence can be set from the Consequence Details Form:

Section 2 – Interface

Title	The title of the consequence. The consequence title is displayed in the top section of the consequence details on the bowtie model.  When a new consequence is created, the consequence title is set by default. The default title for a consequence is “Consequence #”, where # is an automatically enumerated integer value. When a consequence is created, the integer will be set to the lowest integer value greater than zero which has not already been used in the study. It is highly recommended that consequence titles be unique, however this is not a requirement.
Consequence Description	A description of the consequence. The consequence description is displayed in the lower section of the consequence details on the bowtie model.  The consequence description is generally used to give any background information related to the cause.
Severity	The severity of the consequence. The severity of the consequence can be subdivided into five different categories: • Safety Severity: The severity of damage the consequence can cause to the safety and well-being of on-site personnel. • Environment Severity: The severity of damage the consequence can cause to the environment. • Asset Severity: The severity of damage the consequence can cause to on-site assets or equipment.

	• Community Severity: The severity of damage the consequence can cause to the community at large. • Reputation Severity: The severity of damage the consequence can cause to the reputation of a company or organization. By default, the severity of each of these categories can be classified as VL (Very Low), L (Low), M (Medium), H (High), or VH (Very High), in each category's accompanying dropdown menu, as shown below:  User input Severity classifications can be added and modified in the Risk Criteria page in the Consequence Category subpage (See Section 2.11).
Color	The color of the consequence, as it appears on the bowtie diagram. The color defaults to Kenexis Blue but can be changed to any number of preprogrammed colors, or to the color of your choosing using a selection interface. This interface can be accessed using the More button and closed with the Less button. 

	 Once you have your desired color, hit the Choose button to lock it in. If you wish to close the color interface, you can hit the Cancel button.
Notes	Any other notes or comments relating to the consequence.

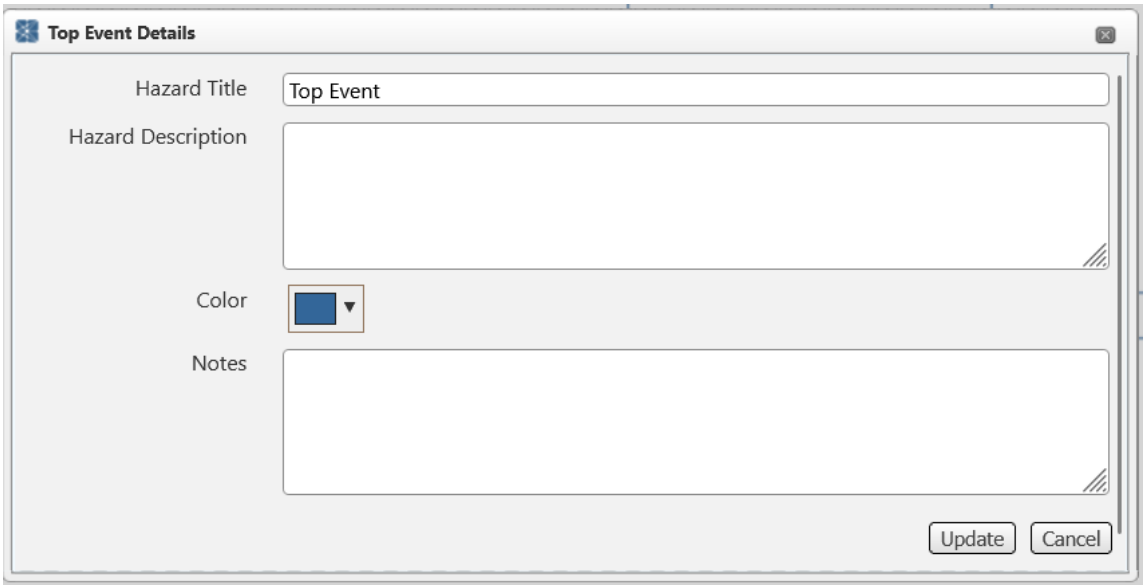
Once you have modified the desired details, hit the Update button to apply your changes, or hit the Cancel button to leave the Consequence Details Form.

2.12 The Top Event Details Form

The Top Event Details Form is a window for entering information about the properties of a top event model. You can access the Top Event Details Form from the Bowtie Interface by double-clicking on the desired top event within the bowtie diagram, or by clicking on the Edit button for the desired top event.

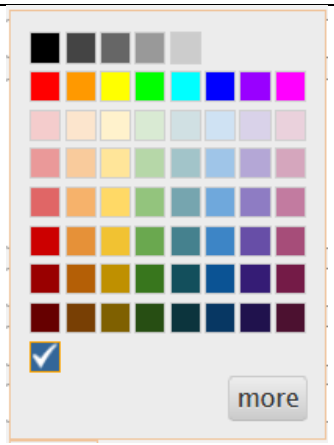
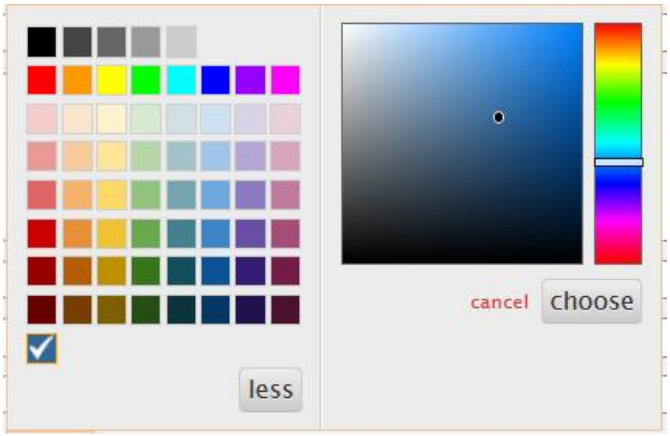
The Top Event Details Form is shown below:

Section 2 – Interface



The following properties for a top event can be set from the Top Event Details Form:

Title	The title of the top event. It is recommended that this title be unique, however it is not required.
Hazard Description	The description of the hazard. The top event is the loss event being studied in the bowtie diagram. A description of the top event may be a loss of containment in the process of hazardous material, energy, etc.
Color	The color of the top event, as it appears on the bowtie diagram. The color defaults to Kenexis Blue but can be changed to any number of preprogrammed colors, or to the color of your choosing using a selection interface. This interface can be accessed using the More button and closed with the Less button.

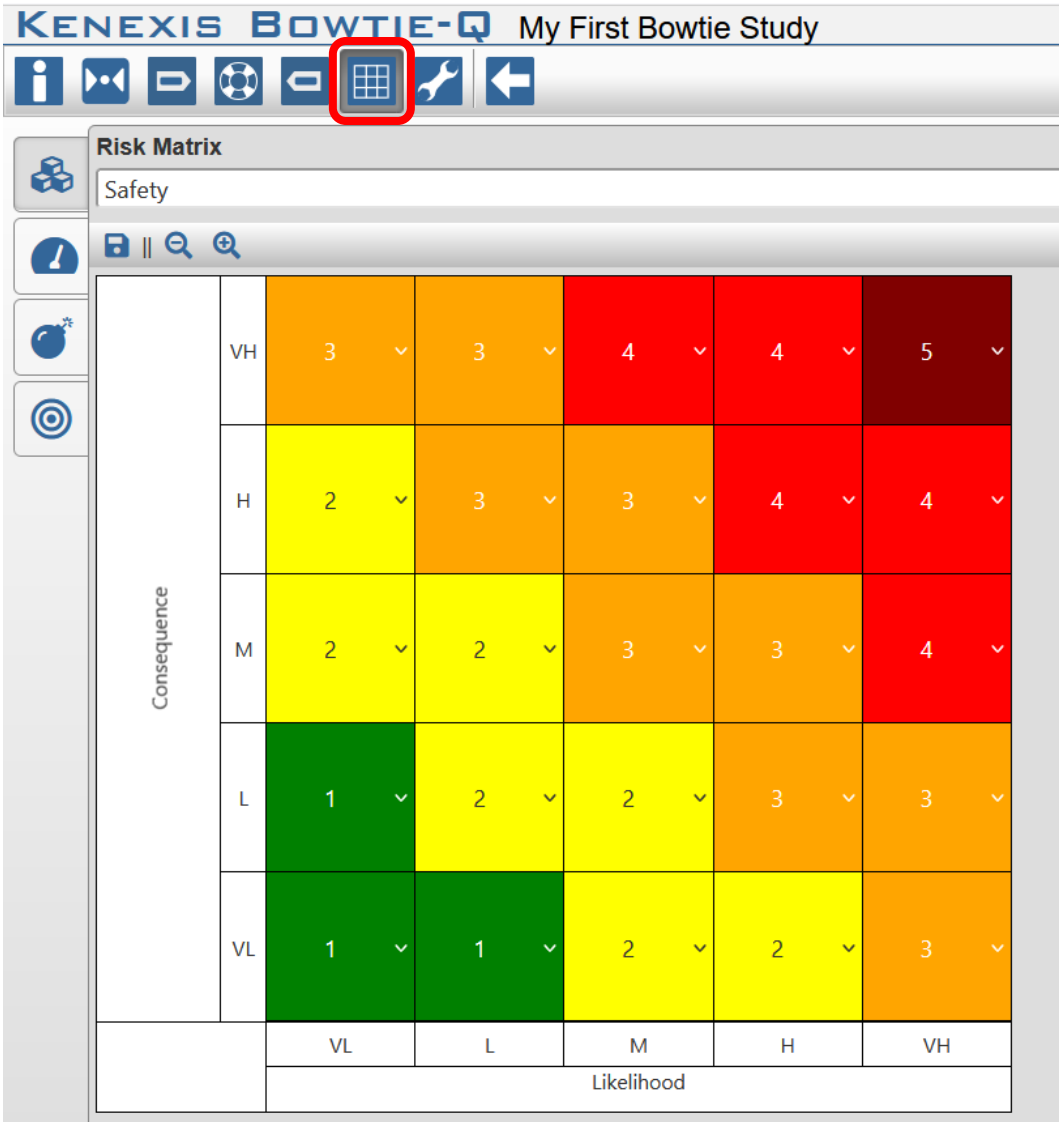
	  Once you have your desired color, hit the Choose button to lock it in. If you wish to close the color interface, you can hit the Cancel button.
Notes	Any other notes or comments relating to the top event.

Once you have modified the desired details, hit the Update button to apply your changes, or hit the Cancel button to leave the Top Event Details Form.

2.13 The Risk Criteria View

The Risk Criteria page contains different modifiable criteria for conducting risk assessments using a risk matrix. The Risk Criteria page can be reached by clicking on the Risk Criteria icon in the Navigation Toolbar, shown below:

Section 2 – Interface

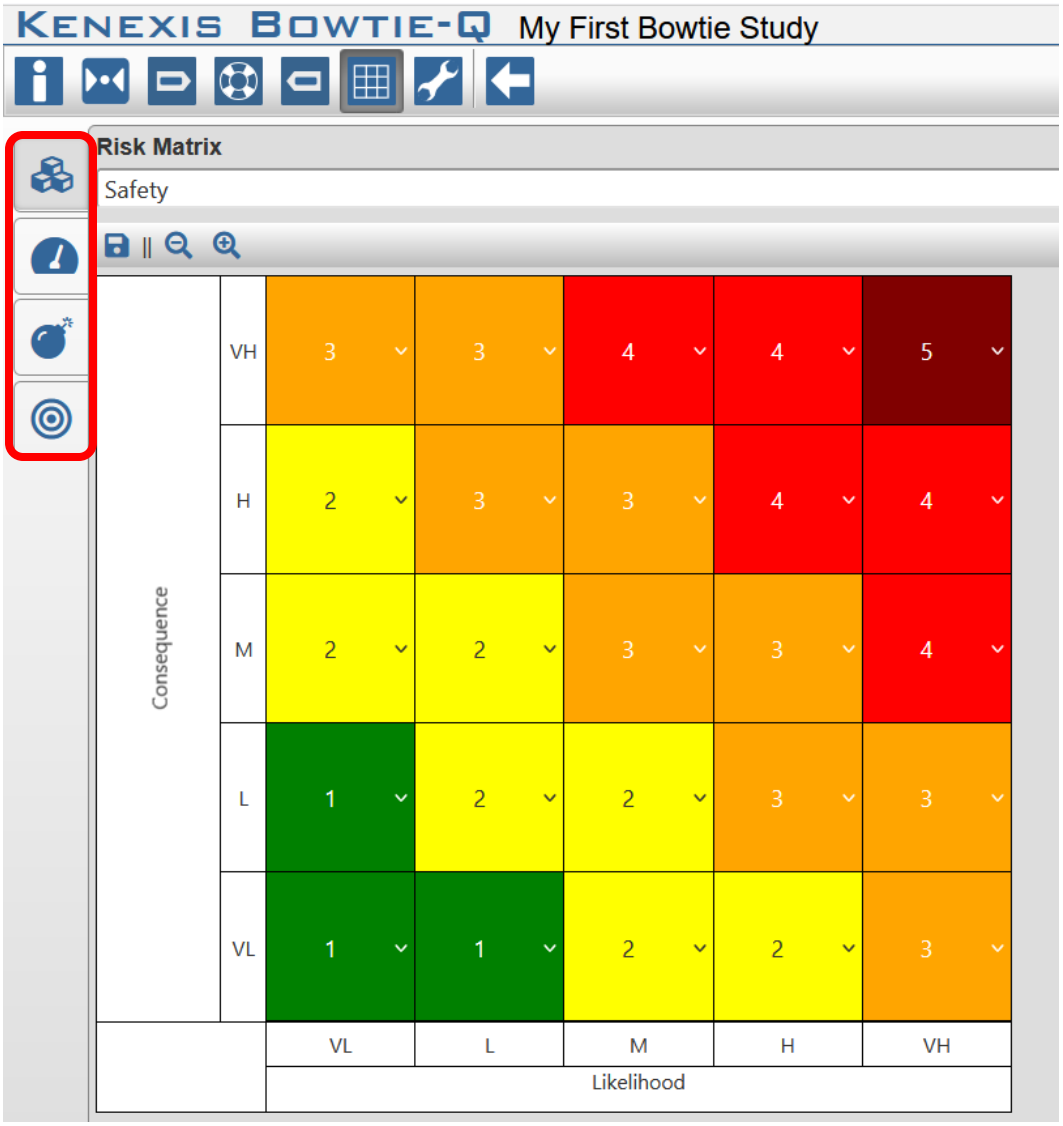


Risk matrices are constructed as a table with consequences on each row and likelihoods on each column.

2.11.1 The Risk Criteria Side Toolbar

The Risk Criteria side toolbar is on the left side of the Risk Criteria page, as shown below. This toolbar allows you to navigate between pages within the Risk Criteria page.

Section 2 – Interface



Section 2 – Interface

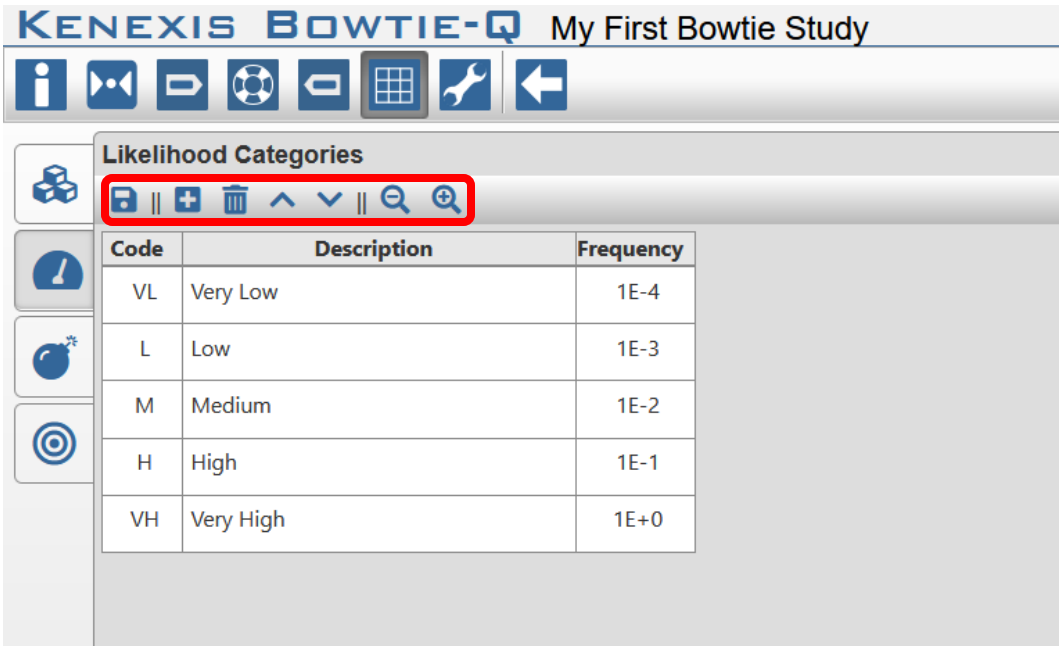
This section details the available buttons on the side toolbar:

Button	Description
	The Risk Matrix button will navigate to the Risk Matrix page. On this page you can make changes to individual entries in the risk matrix by assigning risk rankings to matrix intersections.
	The Likelihood Categories button will navigate to the Likelihood Categories page. On this page you can add likelihood columns to the risk matrix and edit likelihood category parameters.
	The Consequence Categories button will navigate to the Consequence Categories page. On this page you can add consequence rows to the risk matrix and edit consequence category parameters.
	The Risk Rankings button will navigate to the Risk Rankings page. On this page you can identify, describe and rank risk as well as change the colors for entries in the risk matrix by category.

Section 2 – Interface

2.11.2 The Risk Criteria Main Controls

The Risk Criteria main controls can be found at the top of each subpage within the Risk Criteria page, as shown below. These controls allow you to perform actions within the subpage.



Code	Description	Frequency
VL	Very Low	1E-4
L	Low	1E-3
M	Medium	1E-2
H	High	1E-1
VH	Very High	1E+0

2.11.2.1 Saving Changes

This control allows you to save any changes you make to any subpage within the Risk Criteria page. NOTE: If you leave the subpage without saving your changes, they will be lost.

2.11.2.2 Adding and Deleting Rows in the Table

The Add New Row button allows you to add a new table row beneath your selected table row. You must select a row to perform this action.

The Delete Row(s) allows you to delete table row(s). You must select a row or rows to perform this action. A warning message will pop up to confirm your selection.

These controls are not present on the Risk Matrix page.

Section 2 – Interface

2.11.2.3 Moving Rows Up and Down in the Table

The Move Row Up button allows you to move a table row above another. You must select a row to perform this action.

The Move Row Down button allows you to move a table row below another. You must select a row to perform this action.

These controls are not present on the Risk Matrix page.

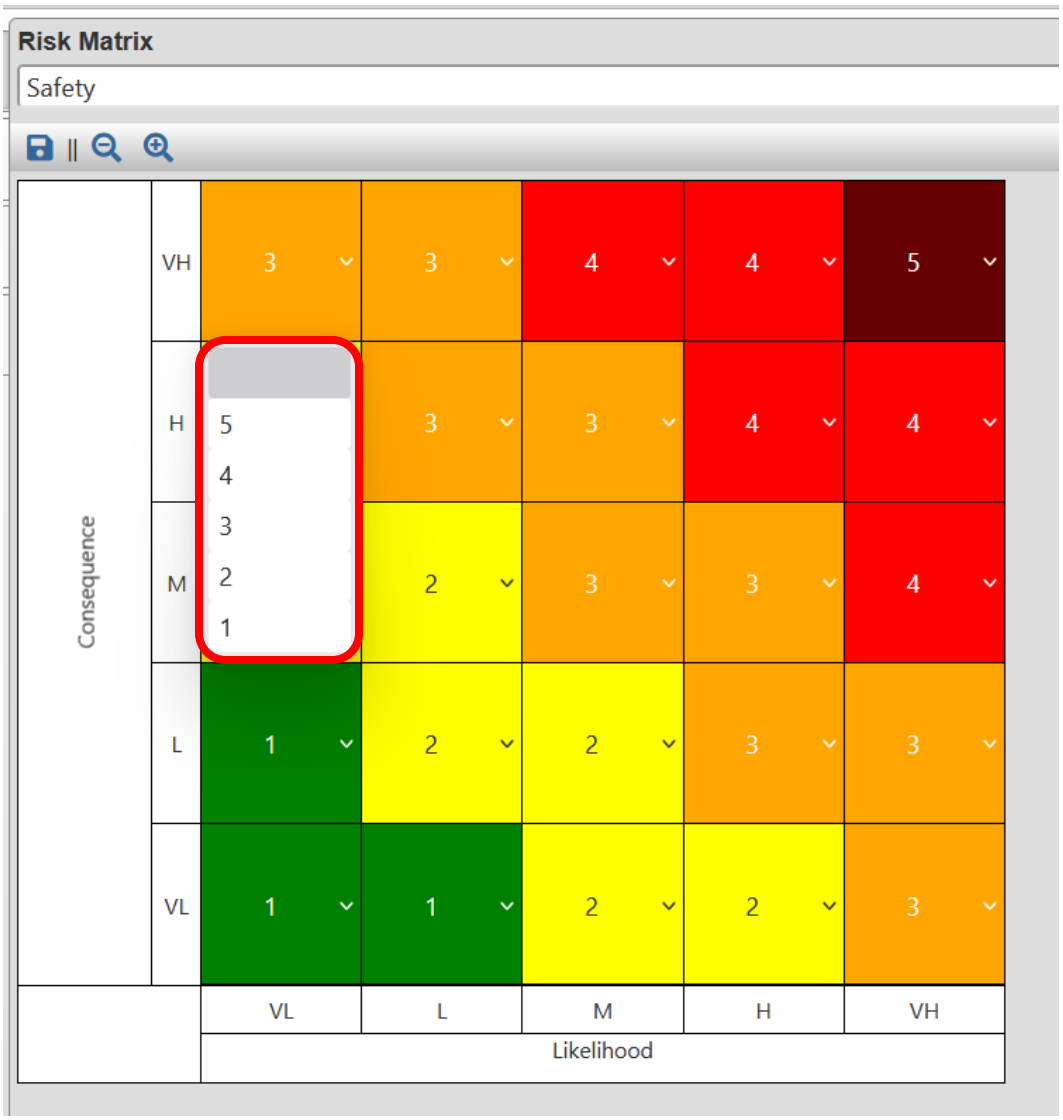
2.11.2.4 Zooming In and Out

By default, the zoom of the Risk Criteria page is always reset on 100% when the diagram is loaded. Clicking the minus magnifying glass will zoom out 5%. Clicking the plus magnifying glass will zoom in 5%.

Section 2 – Interface

2.11.3 The Risk Matrix Page

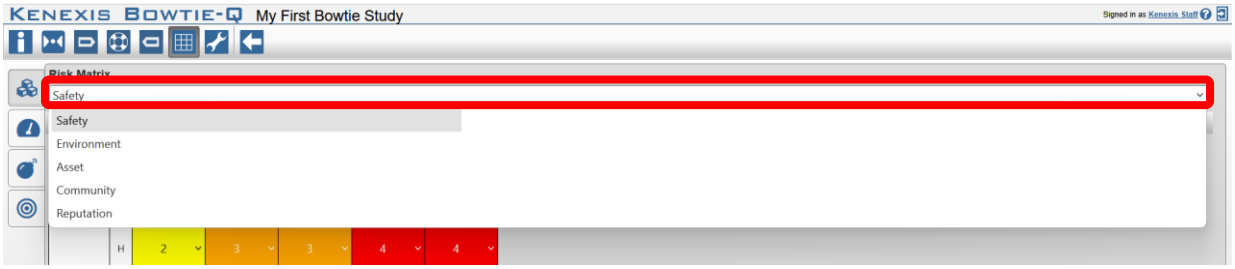
The Risk Matrix page allows the user to modify a default risk matrix. Each entry in the risk matrix can be modified using the dropdown menu, as shown below:



The parameters of the risk matrix, such as the number of likelihood columns, the number of consequence rows, the codes for each column and row, and the number and colors of the dropdown menu for each entry are modifiable in the Likelihood Categories, Consequence Categories, and Risk Rankings pages. The purpose of the risk matrix page is to assign risk rankings to risk matrix intersections.

Section 2 – Interface

In addition, a Risk Matrix exists for each consequence type (safety, environment, asset, reputation & community). To change between the different consequence types, simply click the drop-down window near the top of the workspace and click on the type of consequence you wish to select, as shown below:

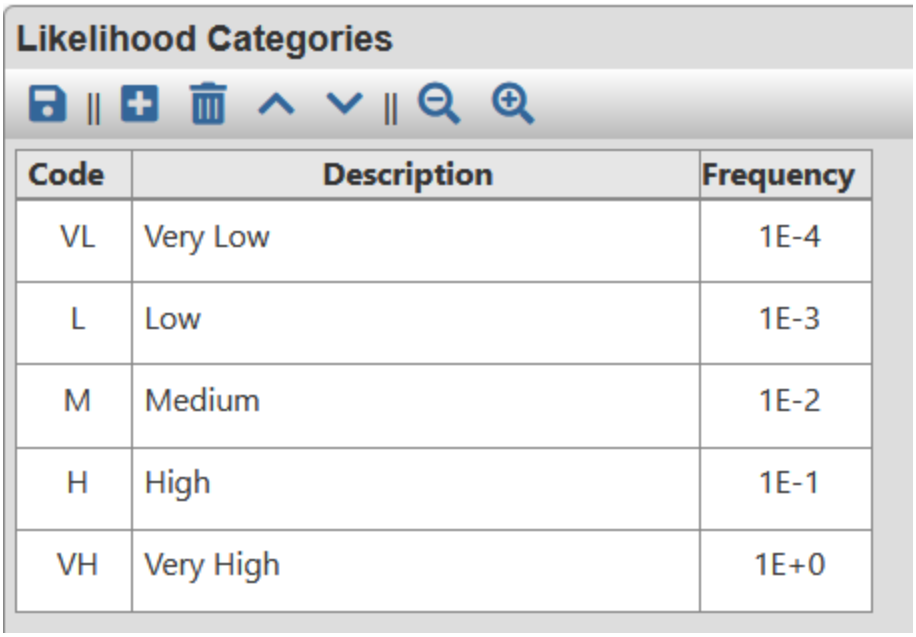


2.11.4 The Likelihood Categories Page

The Likelihood Categories page, as seen below, allows the user to define likelihoods and to assign a frequency and code to each one. When choosing likelihoods, the codes will populate a drop-down list that represents the frequency at which a consequence of that magnitude can be tolerated by the organization. The user can select a likelihood from this menu. Each code has a corresponding extended verbal description.

The frequency column is used as a place to describe the likelihood in terms of frequency. Likelihood categories are not used in Bowtie-Q™ but are maintained in the user interface for consistency with Open-PHA®. The values in this column are used for comparison against a calculated estimated event frequency to determine if tolerable risk is achieved.

Section 2 – Interface

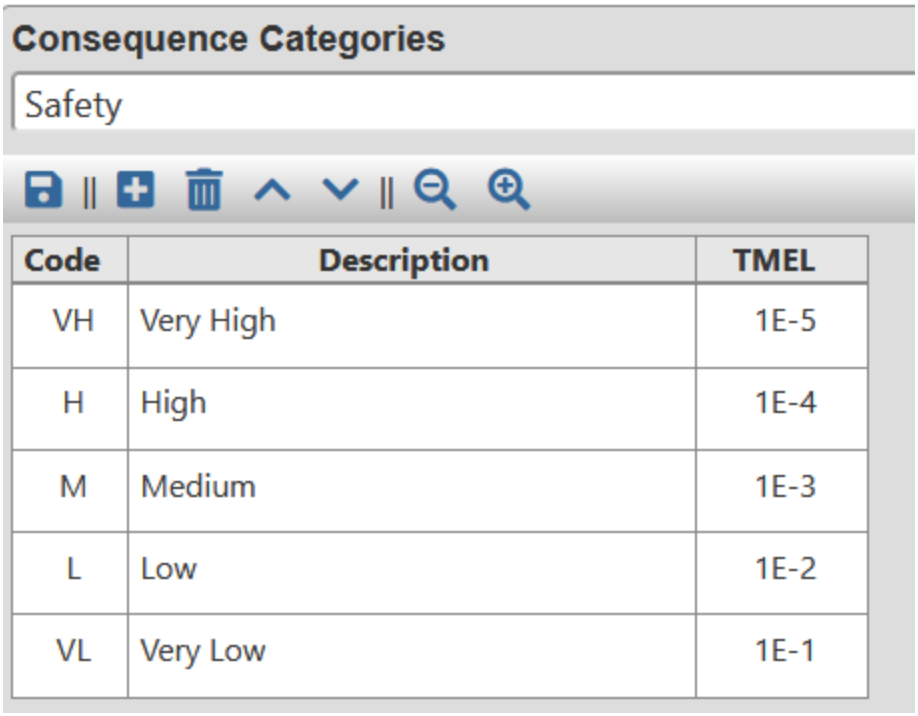


Code	Description	Frequency
VL	Very Low	1E-4
L	Low	1E-3
M	Medium	1E-2
H	High	1E-1
VH	Very High	1E+0

2.11.5 The Consequence Categories Page

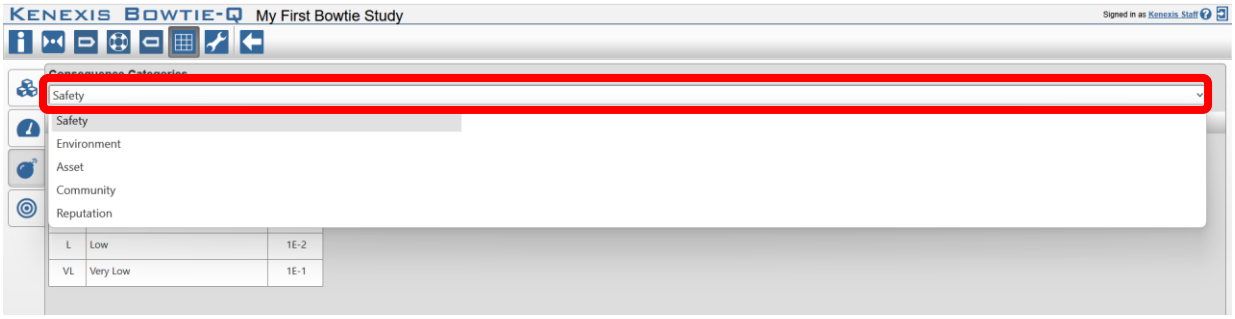
The Consequence Categories Page, seen below, is used to define consequences used in the risk matrix. The code will be used in a drop-down list on the consequence details form to select a consequence severity. The Target Mitigated Event Likelihood (TMEL) entered in this table is the TMEL used in quantitative calculations to determine whether the calculated level of risk is tolerable given the consequence severity selected. Each code has a corresponding description.

Section 2 – Interface



Code	Description	TMEL
VH	Very High	1E-5
H	High	1E-4
M	Medium	1E-3
L	Low	1E-2
VL	Very Low	1E-1

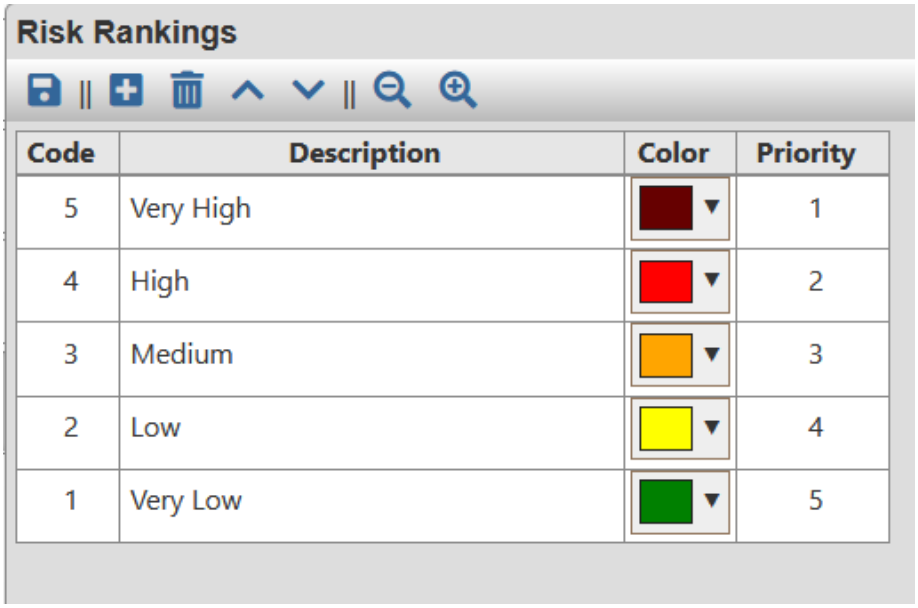
In addition, a Consequence Categories table exists for each consequence type (safety, environment, asset, reputation & community). To change between the different consequence types, simply click the drop-down window near the top of the workspace and click on the type of consequence you wish to select, as shown below:



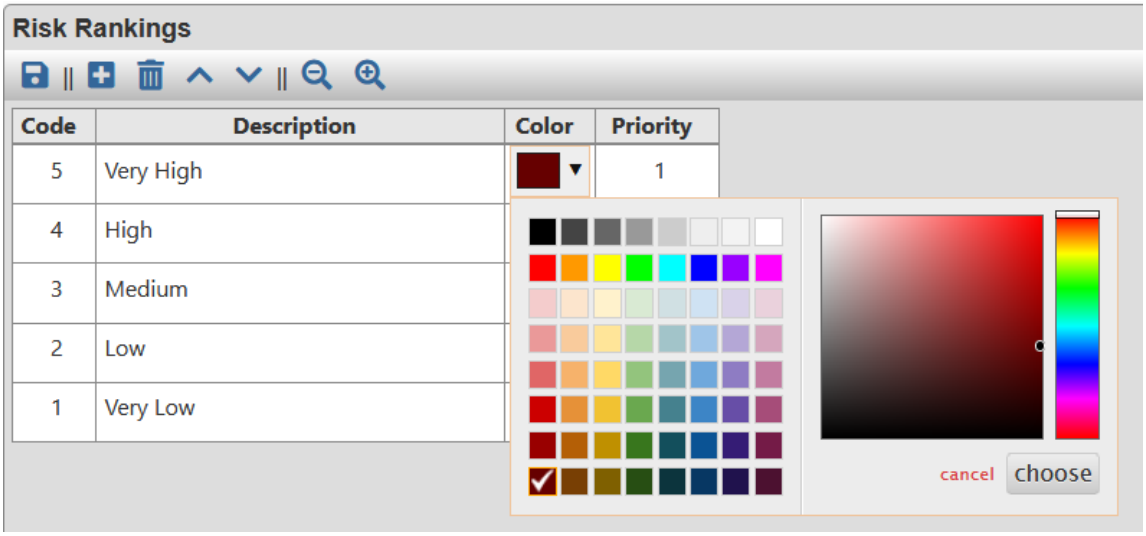
2.11.6 The Risk Rankings Page

The Risk Rankings Page houses the risk ranking table. This table allows the user to identify, describe and rank risks. The codes used in the Risk Rankings page are the codes that show up on each entry in the Risk Matrix. The Risk Rankings table includes a column to assign a color to a code and a risk rank.

Section 2 – Interface



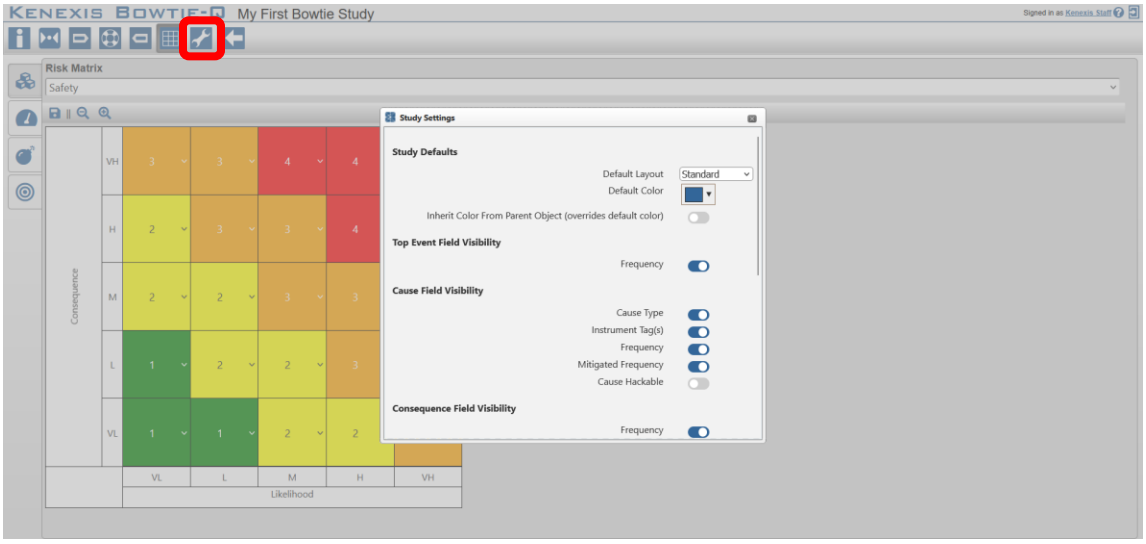
Each risk ranking has a default color but can be changed to any number of preprogrammed colors, or to the color of your choosing using a selection interface, as shown below. Once you have your desired color, hit the Choose button to lock it in. If you wish to close the color interface, you can hit the Cancel button.



Section 2 – Interface

2.14 Study Settings

The Study Settings page manages all the fields in the study and allows for a high degree of customization. The Study Settings page can be reached by clicking on the Study Settings icon in the Navigation Toolbar, as shown below:



The Study Settings page allows you to hide or unhide fields within the study, set the default layout, the default color for objects. To hide a column/field, simply click on the slider or text and the slider will turn gray. To make a column visible, click on either the slider on the right, or the text itself. If the slider is blue, then the field is visible.

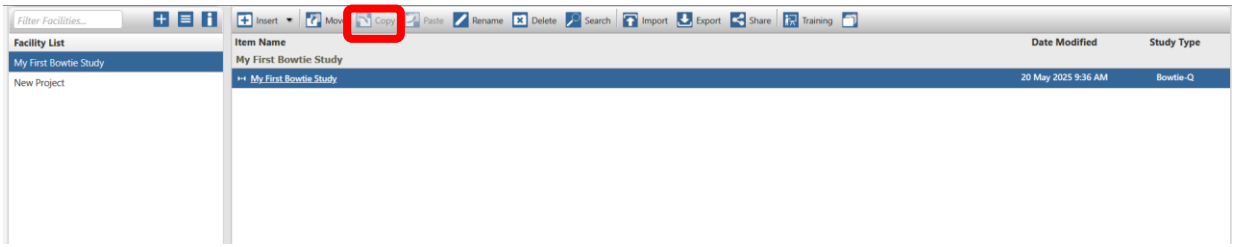
To change the default color for objects, you can use the default color setting to choose from preprogrammed colors, or to choose a different color using a selection interface. This interface can be accessed using the More button and closed with the Less button. Once you have your desired color, hit the Choose button to lock it in. If you wish to close the color interface, you can hit the Cancel button. The Inherit Color from Parent Object slider allows you to toggle whether child objects (such as degradation factors and controls originating from a safeguard) inherit the color of the parent or resort to the study's default color.

Once you have modified the desired details, hit the Update button to apply your changes, or hit the Cancel button to leave the Study Setting page.

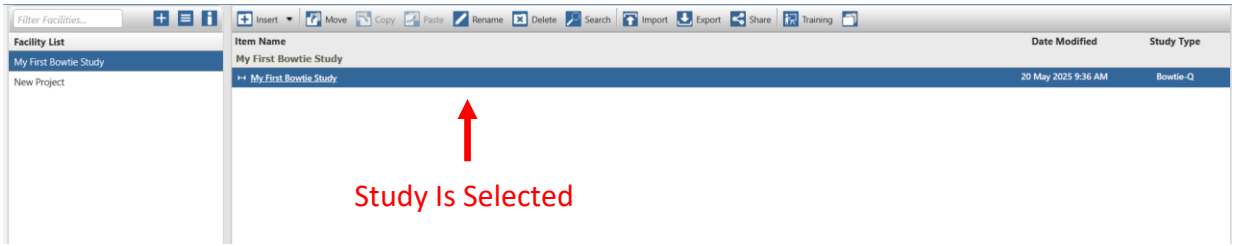
Section 2 – Interface

2.15 Copying a Study

A Bowtie-Q™ study can be copied from the KISS Manager Study manager page. The KISS study manager page is the main page in the KISS Manager application, it is the default landing page when logging into your KISS account, shown below:



Studies can be copied by clicking on the copy study button in the main navigation toolbar, highlighted above. If there is no study selected the copy study button will be disabled and rendered with transparency, as shown in the above figure. Once a Bowtie-Q™ study is selected, the copy study button will enable, allowing the selected study to be copied as shown below. A Bowtie-Q™ study can be selected from the Study List by left clicking on the row of the desired study. When selected, the row will be highlighted blue.

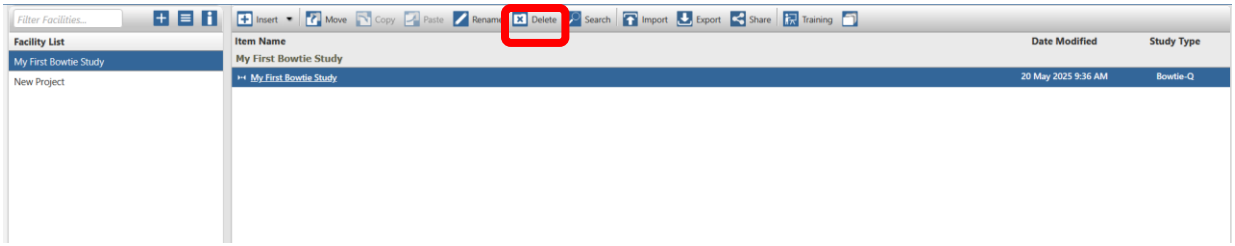


Studies can only be copied within the Facility where they were created. When a study is copied the new instance of the study will be renamed to “Study Name – Copy”. Where Study Name is the name of the original study.

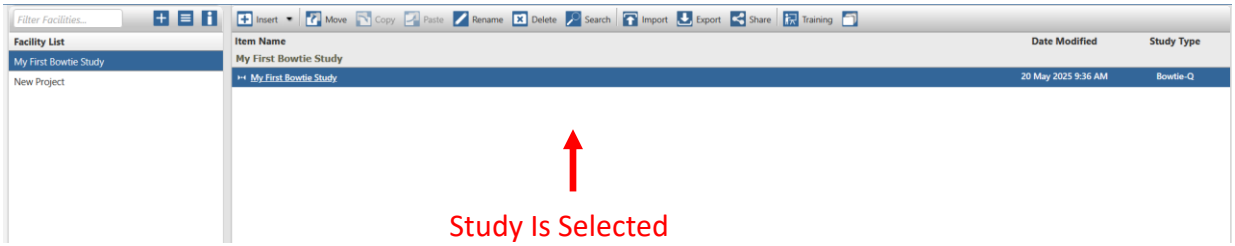
2.16 Deleting a Study

A Bowtie-Q™ study can be deleted from the KISS Manager Study manager page. The KISS study manager page is the main page in the KISS Manager application, it is the default landing page when logging into your KISS account, shown below:

Section 2 – Interface



Studies can be deleted by clicking on the delete button in the main navigation toolbar, highlighted above. If there is no study selected the delete study button will be disabled and rendered with transparency, as shown in the above figure. Once a study is selected, the Delete button will enable, allowing the selected study to be deleted. A Bowtie-Q™ study can be selected from the Study List by left-clicking on the row of the desired study. When selected, the row will be highlighted blue.



Section 3 – Calculation Details

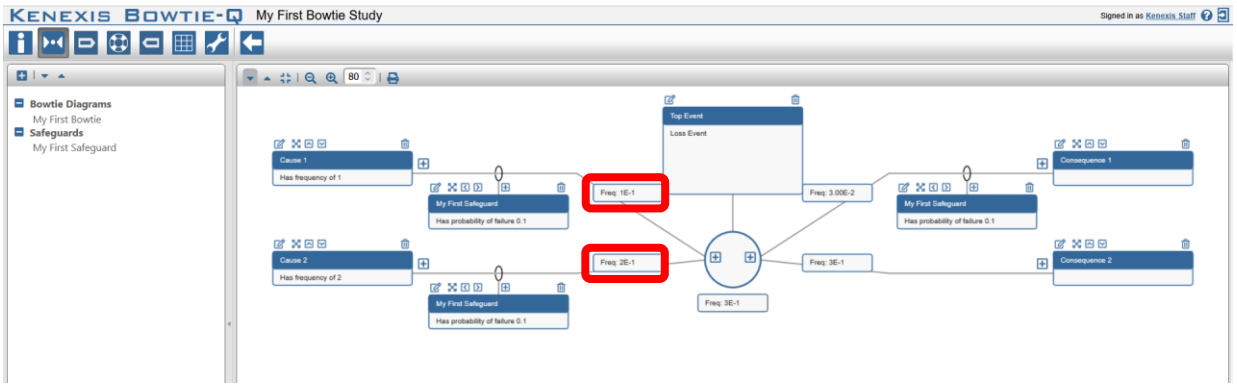
This section details the calculations methods used by Bowtie-Q™ to determine the frequency of consequences as a function of the frequency of causes (units of 1/time), and the probability of failure for safeguards.

3.1 Mitigated Cause Frequency Calculations

Mitigated cause frequency calculations are used to determine the frequency of a cause occurring, accounting for mitigation factors such as safeguards. Mitigated cause frequencies can by calculated by multiplying a given unmitigated cause frequency by the product of the probabilities of failure of all safeguards between the cause and the top event. If there are no safeguards between the cause and top event, the mitigated cause frequency is simply equal to the unmitigated cause frequency. The formula for calculating a mitigated cause frequency is:

$$f_{cause,mitigated} = f_{cause} * \prod_{i=1}^{n} P_{FD,safeguard\ i}$$

This is equivalent to a logical AND gate between the unmitigated cause frequency and safeguard probabilities of failure. The result is a frequency in units of 1/time.



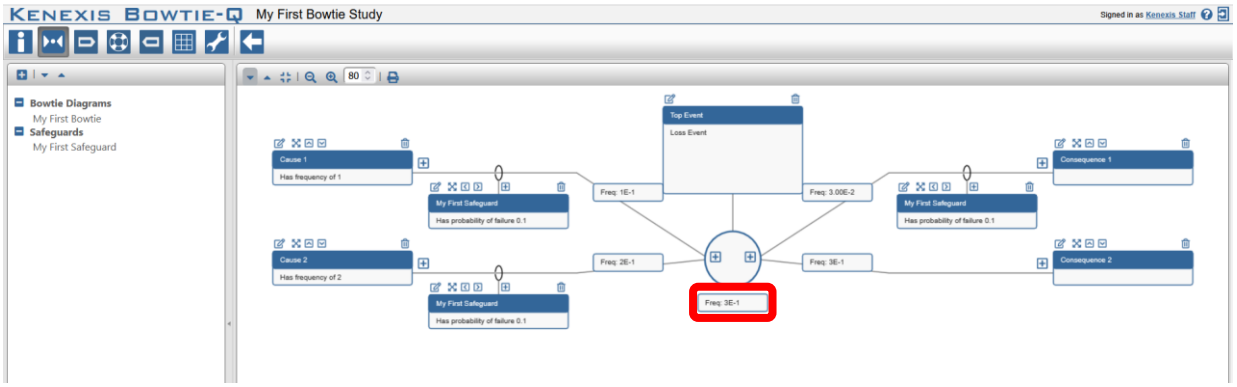
3.2 Top Event Frequency Calculations

Top event frequency calculations are used to determine the frequency of the top event occurring. Top event frequencies can be calculated by summing all mitigated cause frequencies. The formula for calculating the top event frequency is:

$$f_{top\ event} = \sum_{i=1}^{n} f_{cause,mitigated\ i}$$

Section 3 – Calculation Details

This is equivalent to a logical OR gate between the mitigated cause frequencies. The result is a frequency in units of 1/time.

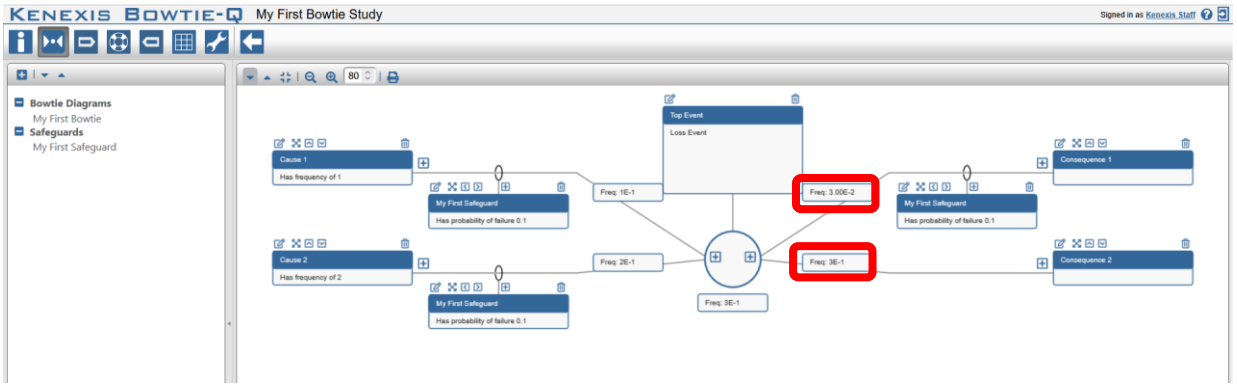


3.3 Consequence Frequency Calculations

Consequence frequency calculations are used to determine the frequency of the consequence occurring. The frequency of the consequence is equal to the top event frequency multiplied by the product of the probabilities of failure of all safeguards between the top event and the consequence. If there are no safeguards between the top event and consequence, the consequence frequency is simply equal to the top event frequency. The formula for calculating the consequence frequency is:

$$f_{consequence} = f_{top\ event} * \prod_{i=1}^{n} P_{FD,safeguard\ i}$$

This is equivalent to a logical AND gate between the top event frequency and safeguard probabilities of failure. The result is a frequency in units of 1/time.



Section 3 – Calculation Details

3.4 Meeting TMEL Criteria

If a consequence severity is selected for any one of the five consequence categories (Safety, Environment, Asset, Community, Reputation), Bowtie-Q™ will compare the consequence frequency against the Target Mitigated Event Likelihood (TMEL) for the consequence severities selected.

To view whether TMEL frequencies are achieved, you can use the Expand button as described in Section 2.3 to see the TMEL frequencies for each category for each of your consequences. In the example process shown below, the example process meets the TMEL for three of the five categories, shown with green circles, but fails two of the five, shown with red circles.