The Cybersecurity Value-at-Risk Framework: Informing Cybersecurity Decisions

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NREL

Contents

1 Project Overview

2 Research Approach

3 Technical Implementation

4 Outlook & Future Work

5 Q&A

Cybersecurity Value-at-Risk Framework Project Overview

- Leverages the architecture of the Distributed Energy Resources Cybersecurity Framework (DER-CF) – www.dercf.nrel.gov
- Targets the risk management process to prioritize action items and associated investments
- Considers various impacting factors such as environmental, economical, safety and operations risks
- Calculates risk, impact, and cyber-resilience scores for determining value at risk
- Prioritizes risk-based recommendations to enhance decision-making

Research Approach

Literature review, scoping, and asset identification

Resources

- Institute of Electrical and Electronics Engineers (IEEE) 1020, *Guide for Control of Small Hydroelectric Power Plants*
- IEEE 1010, *Guide for Control of Hydroelectric Power Plants*
- International Electrotechnical Commission (IEC) 31010, *Risk Assessment Techniques*
- IEC 62270, *Guide for Computer-Based Control for Hydroelectric Power Plant Automation*
- *Dams Sector Cybersecurity Capability and Maturity Model*

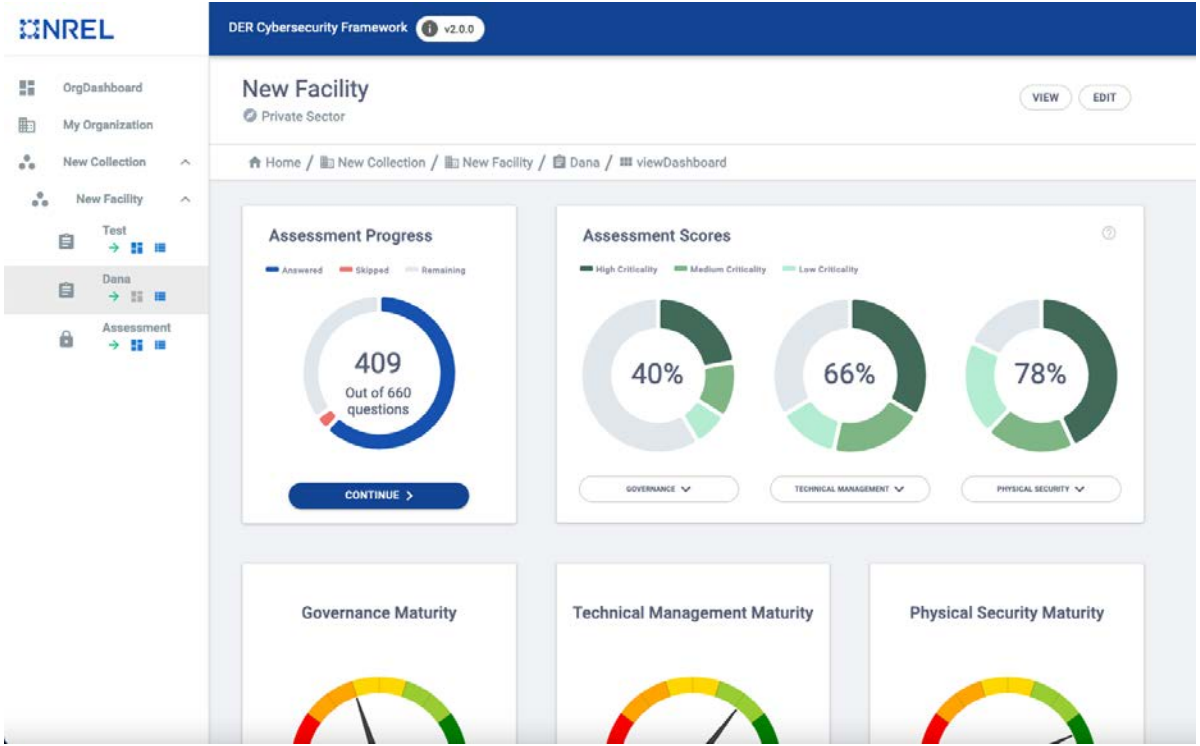
Advancing Cybersecurity Risk Assessment

Moving from maturity-based scoring to semiquantitative risk calculations

DER-CF

Pillar → Domain → Subdomain Model

Answer types/follow-ups and recommendations



Step 1: Hydropower Focused Operations and Assets

- Identify mission-critical hydropower systems
- Highlight areas of cyber concern for hydropower plant operations
- Scope assets that may be vulnerable to cyberattacks

Hydropower Operations	Discipline and Assets	Critical Cyber Assets
Water Conveyance Operation	Gates, penstock, inlet valve, hydraulic actuators, water flow meter	Inlet valve/gate operation system, spill gate control system, powerhouse drainage system, water injection and wicket gate system, remote gate and dam operation system
Generator	Generator rotor and stator, exciter, protective relay, cooling water, air injection, CO2 fire suppression, alarm system, governor	Condition monitoring system, vibration monitoring system, generation load control, generator circuit breaker, protective relay system, alarm system, governor control system
Turbine	Mechanical-Turbine, Electrical-Turbine sensor	Speed sensor, hydro turbine control system, turbine shaft vibration monitoring system
Automation, Control and Protection	Supervisory system, networking equipment, HMI, emergency shutdown system	Speed control and brake monitoring system, routers, switches, gateway devices (firewall, IDS/IPS), controller communication modules, fire and overspeed protection
Substation Operation	Circuit switches, surge arrestor, transformers, line switches	Remote terminal unit, programmable logic controller, protective device, HMI, gateway device
Plan Auxiliary System	Station lighting DC system-UPS and battery Diesel and battery generator	Lighting plant control system, plant security system Plant DC monitoring system Diesel generator monitoring system

Step 2: Impacts and Likelihood Categories

Impact

- Safety
- Environmental
- Economical
- Operational

Generic Control Catalog
*Are commonly used **ports disabled** when not used or changed to site-specific port numbers? Examples include 80 (HTTP), 53 (DNS), 23 (TELNET), 161 (SNMP), 502 (MODBUS), 20000 (DNP3), and 44818 (Ethernet/IP).*
*Is the **operation technology (OT) specific data encrypted or at least password protected**? Examples include schematics, diagrams, control system layouts, etcetera stored either on workstations or databases*
*Are control system devices' **default credentials changed to more secure credentials** before being deployed in production environment?*
*Is there a **robust patch management policy** and control in place where patches to OT/control system devices are first tested in a sandboxed/virtual system environment to identify undiscovered vulnerabilities?*
*Are **secure coding practices** used to prevent malicious code consisting of configuration to inject project files? For ex: Code signing, encryption of sensitive information, restriction of files and directory permissions.*
*Are operational servers and other critical functional components **regularly backed up**? Are those backups offline or offsite, and do you regularly **prove the ability to restore** operations?*

Likelihood Factor	Sub-category	Description
Location	Local	Asset is within boundary/sight of equipment
	Centralized	Asset is remote from controlled equipment, but within the plant
	Off-site	Asset is in a remote location from the plant
Operation Mode	Manual	Each operation needs a separate and deliberate initiation
	Automated	Two or more operations can be started by a single command or initiation
Staff Attendance	Attended	Operator must be physically available to initiate action
	Unattended	Operator can initiate control while off-site

Likelihood Descriptions

Factors affecting the calculation of cyberattack likeliness

Step 3: Define, Assign, and Validate Weighted Values

Security Control Attributes and Metadata

- Establish values and associated weights
- Threat activation mechanism
- Likelihood score depending on operation modes
- MITRE's ATT&CK[1] for industrial control systems (ICS)

  Tactics, techniques, and procedures → assets → vulnerability → mitigation
- Impact considerations to address priorities
- Value-at-risk calculation to inform the need to invest resources

1. https://collaborate.mitre.org/attackics/index.php/Main_Page

Assessment Structure

Domain expansion for hydropower assessment

Domain	Subdomain
Critical Operations	Maintenance Plant Operations Generic Controls Safety
Management	Risk Management Asset Management Identity Management Policies/Procedure Training Communication Networks Personnel/Leadership
Site and Service Control	Physical Protection Access Control Monitoring Information Protection
Dependencies	Grid Operation Business Endpoint Data

CVF 2.0 Technical Implementation

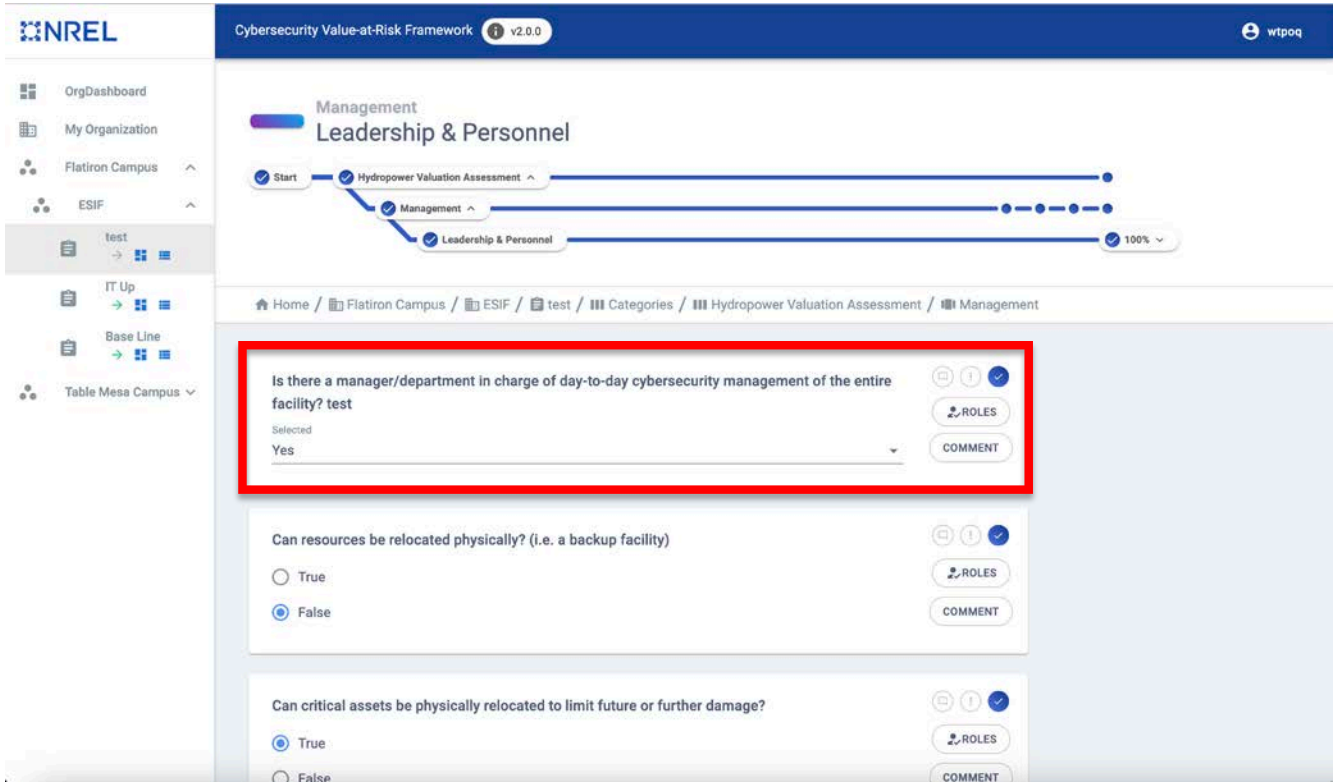
DER-CF Extension and Additional Functions in the Tool

Assessment Controls

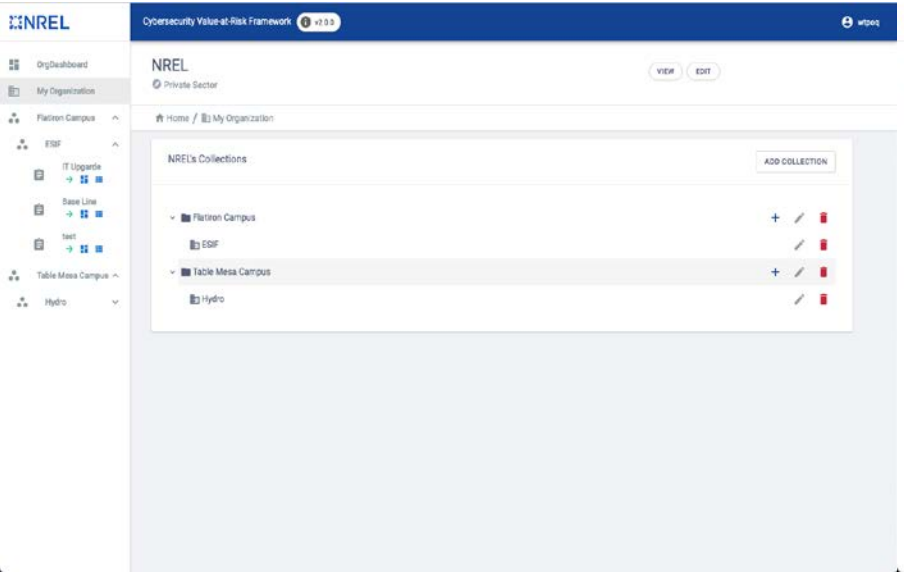
Pillar -> Domain -> Subdomain -> Controls

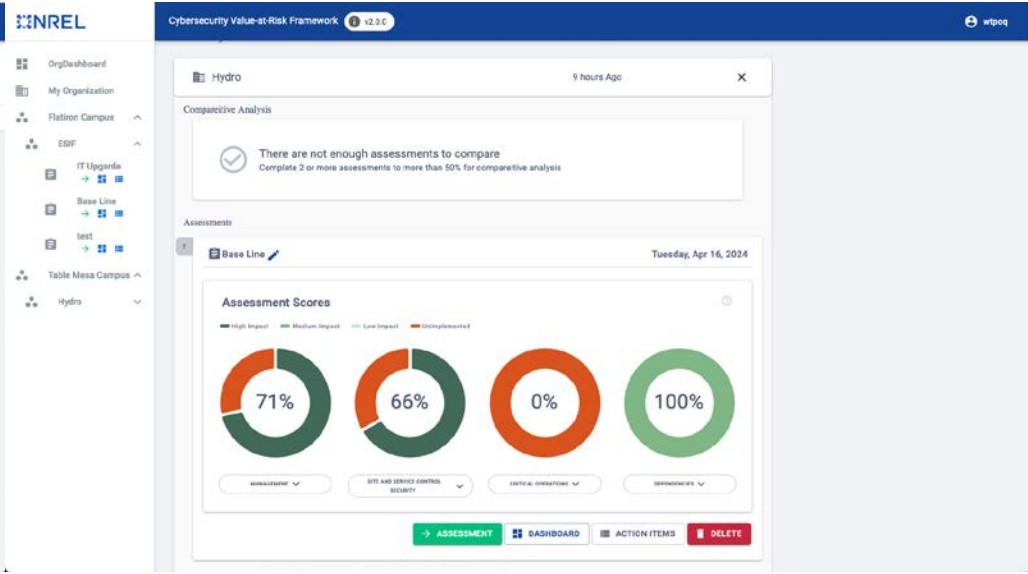
- Impact level
- Action Items
- Metrics
  - NIST CSF Category
  - CIA Triad
  - Impact Category
  - Consequence Category
  - Feasibility

Assessment Scores

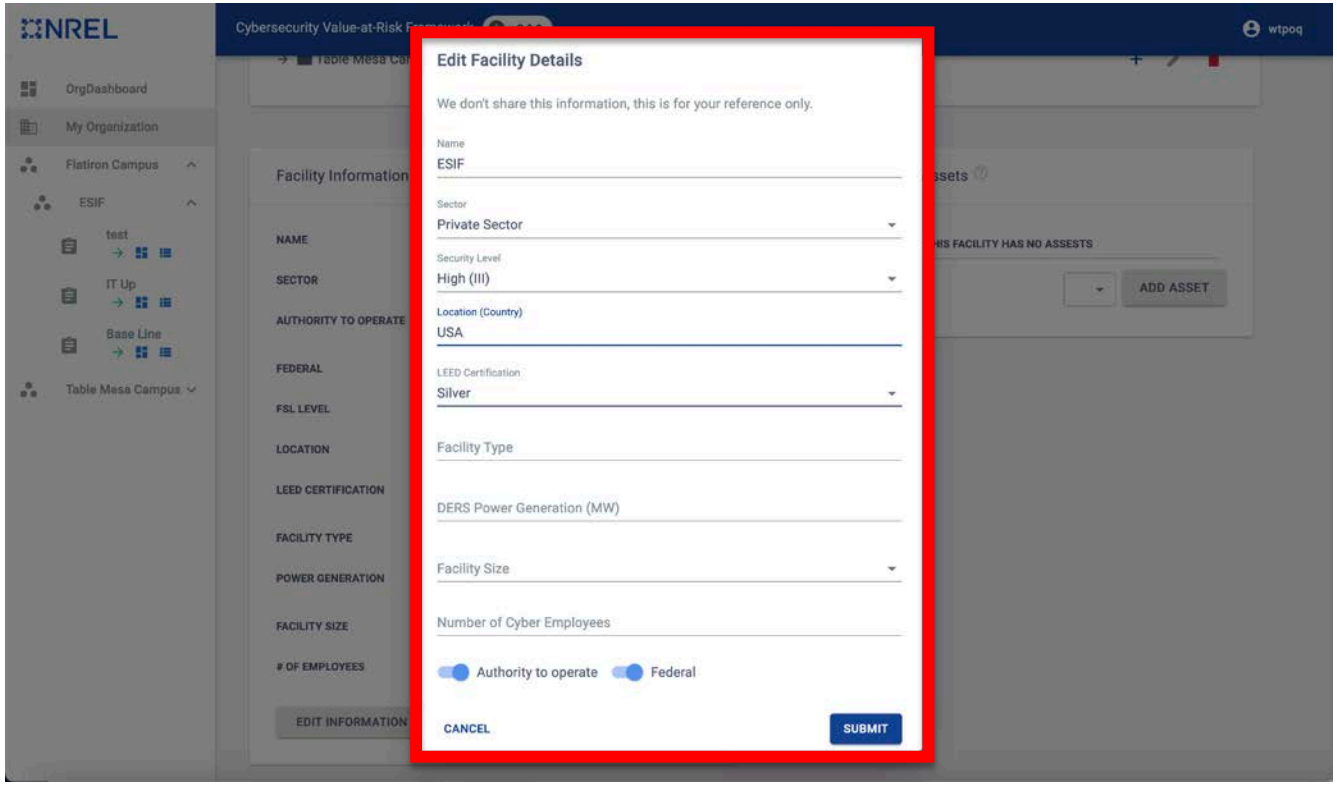


Multiple Facilities and Multiple Assessments

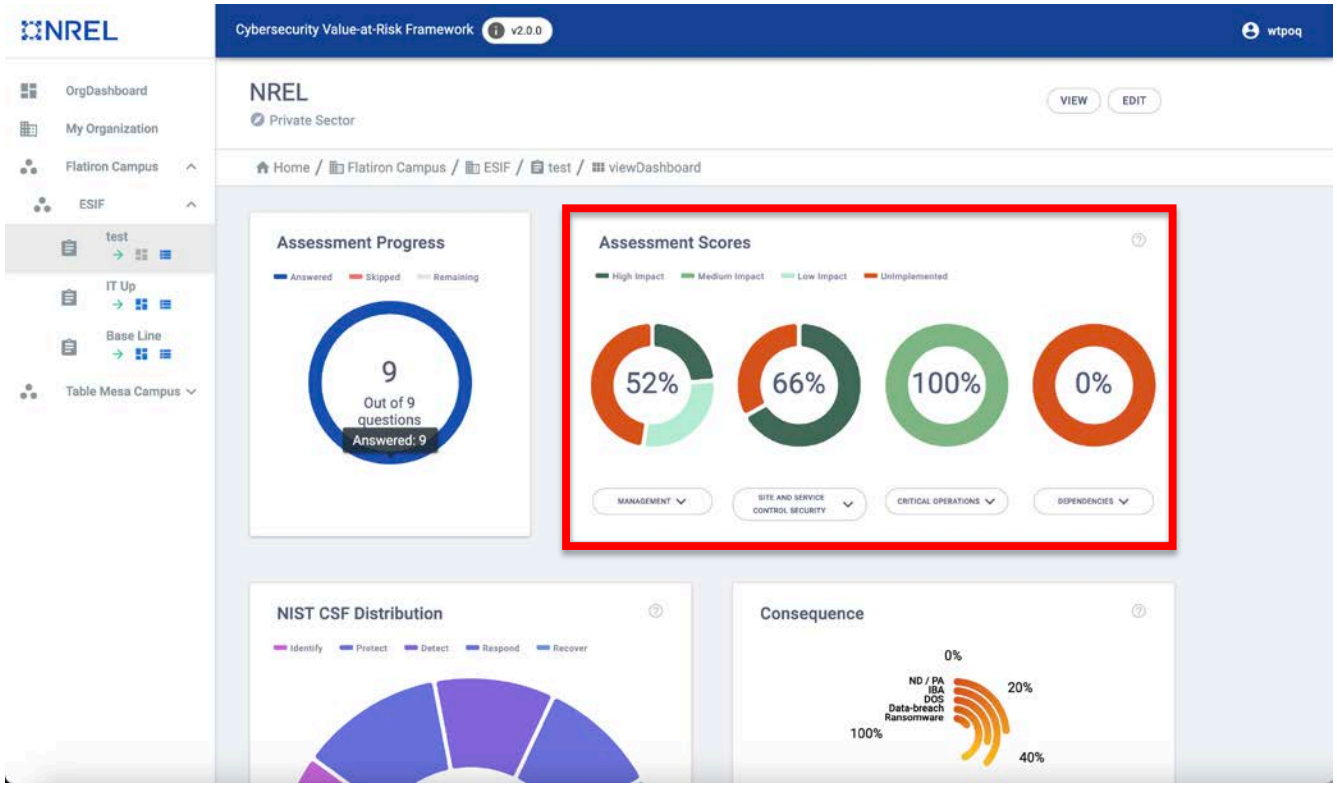




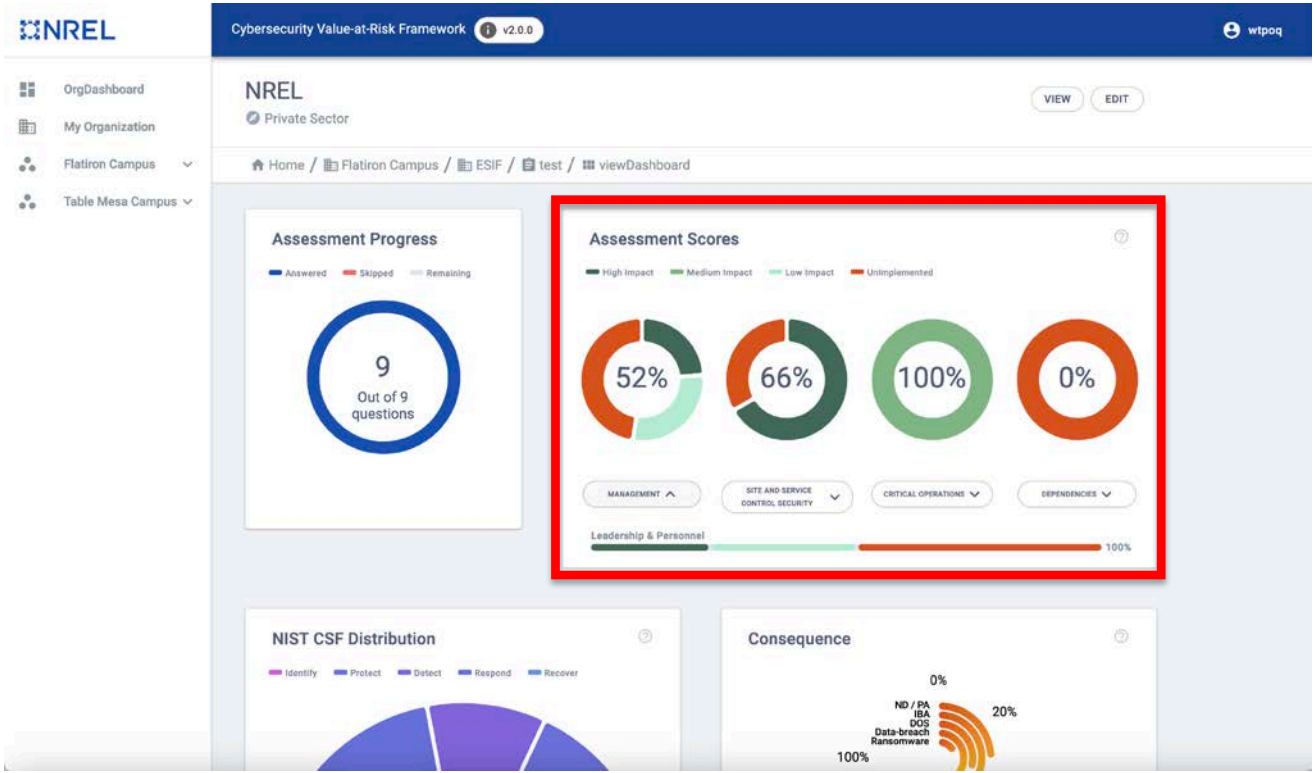
Assessment Scores



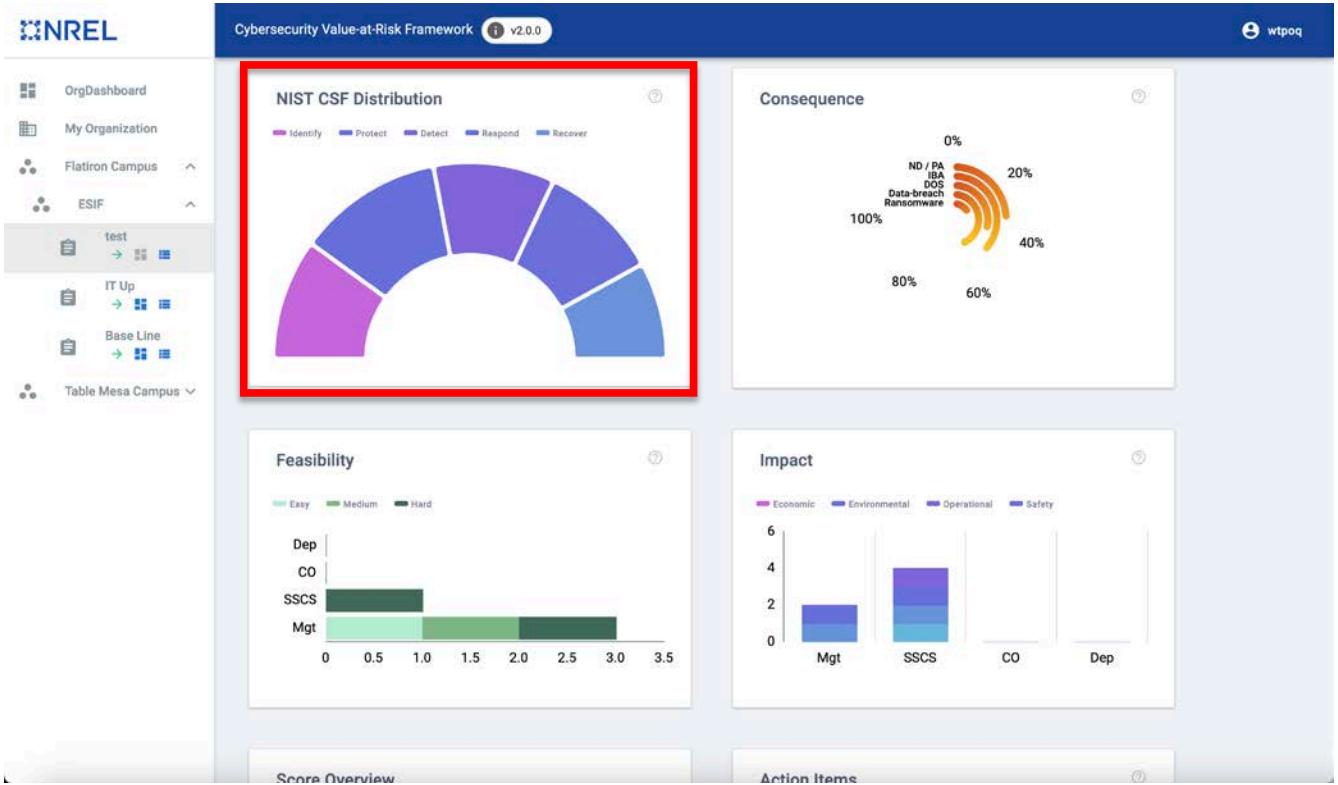
Assessment Scores



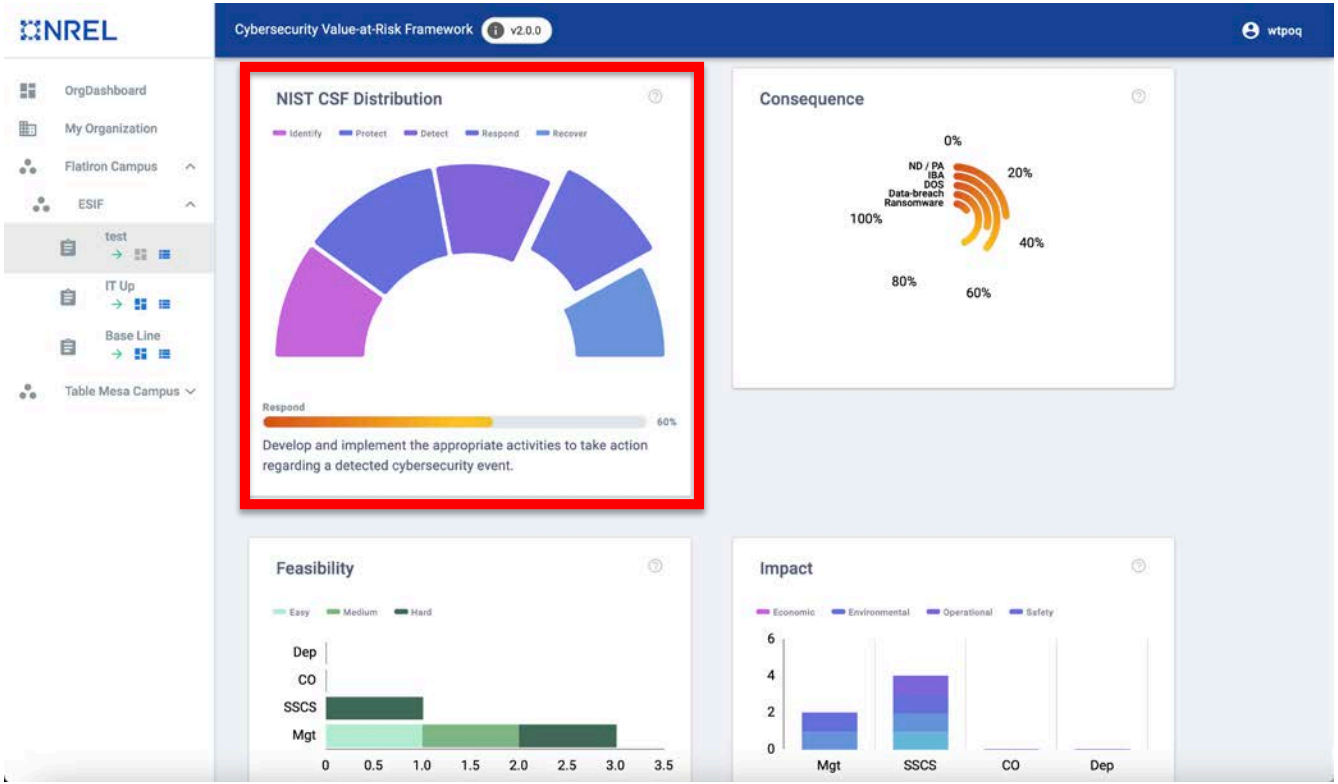
Assessment Scores



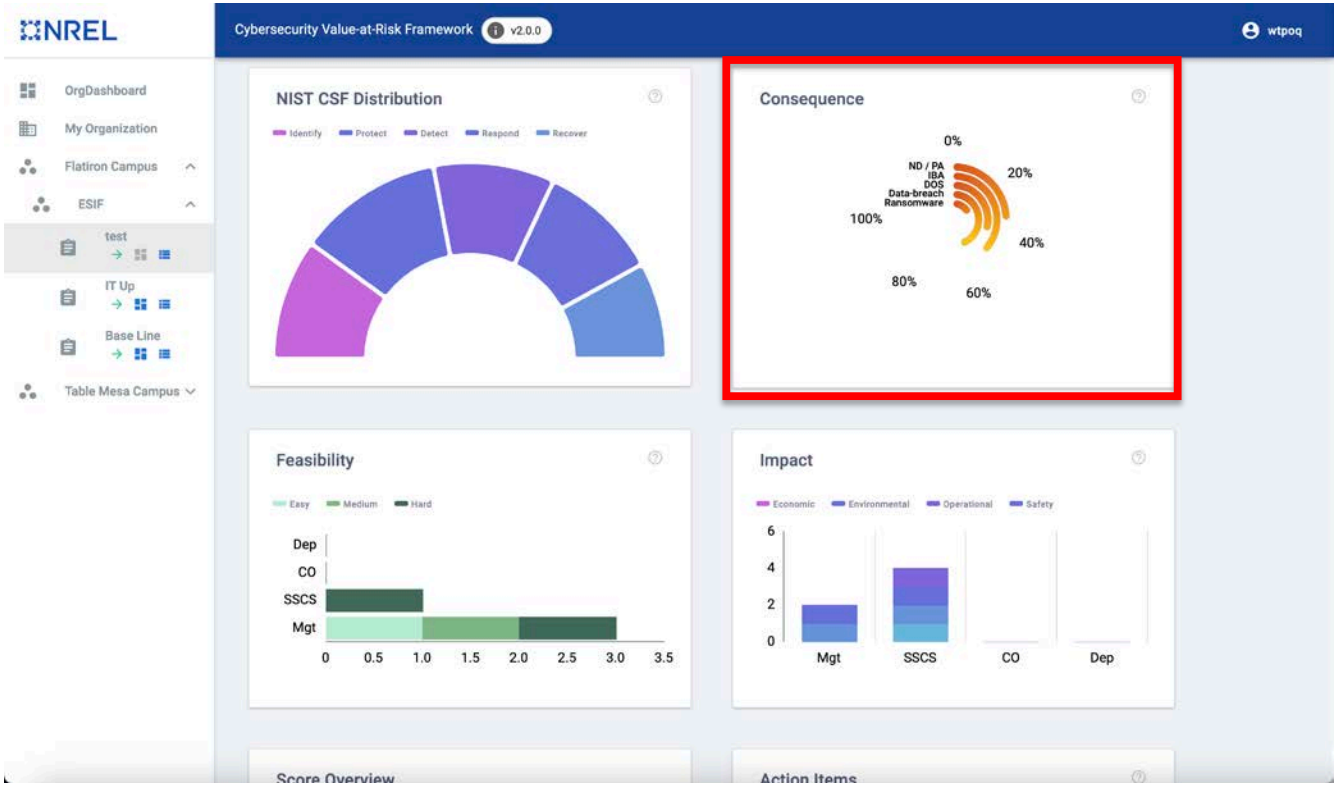
NIST CSF Distribution



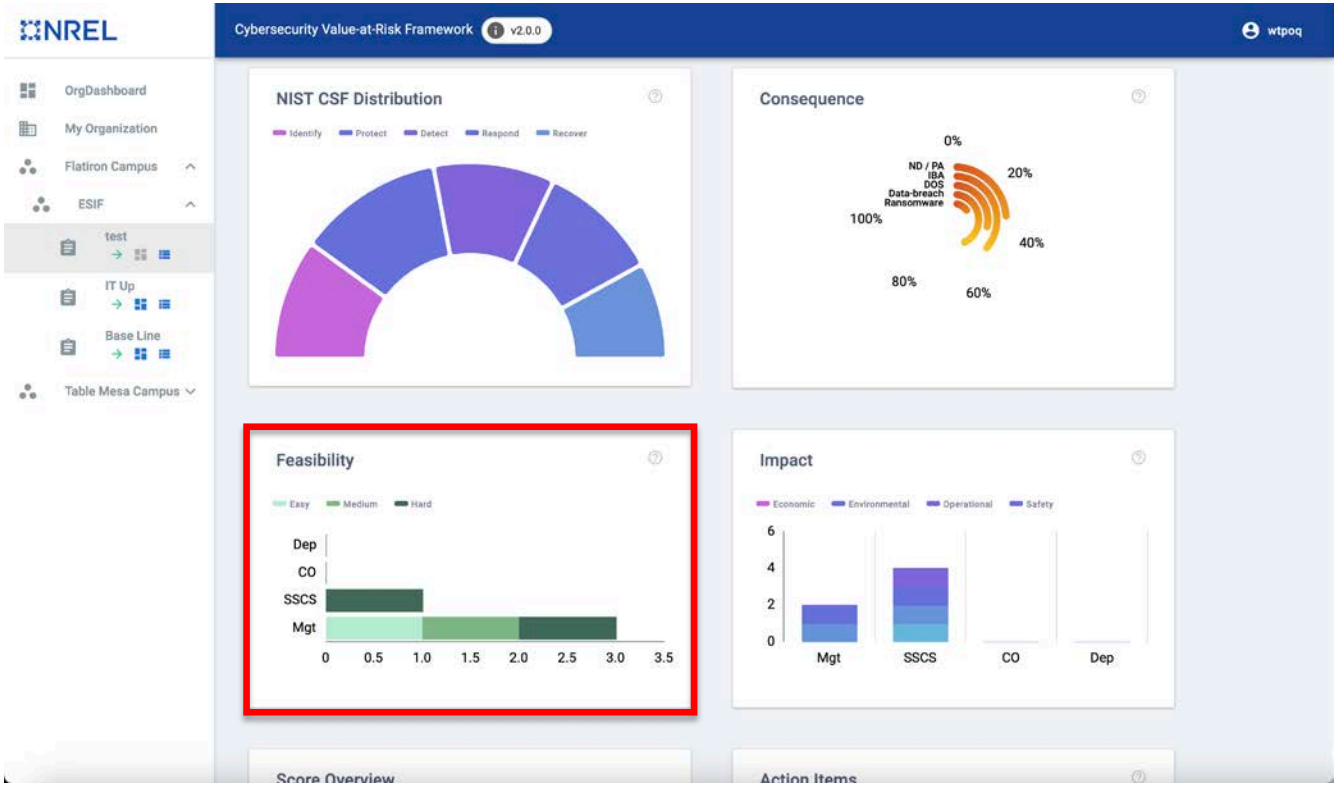
NIST CSF Distribution



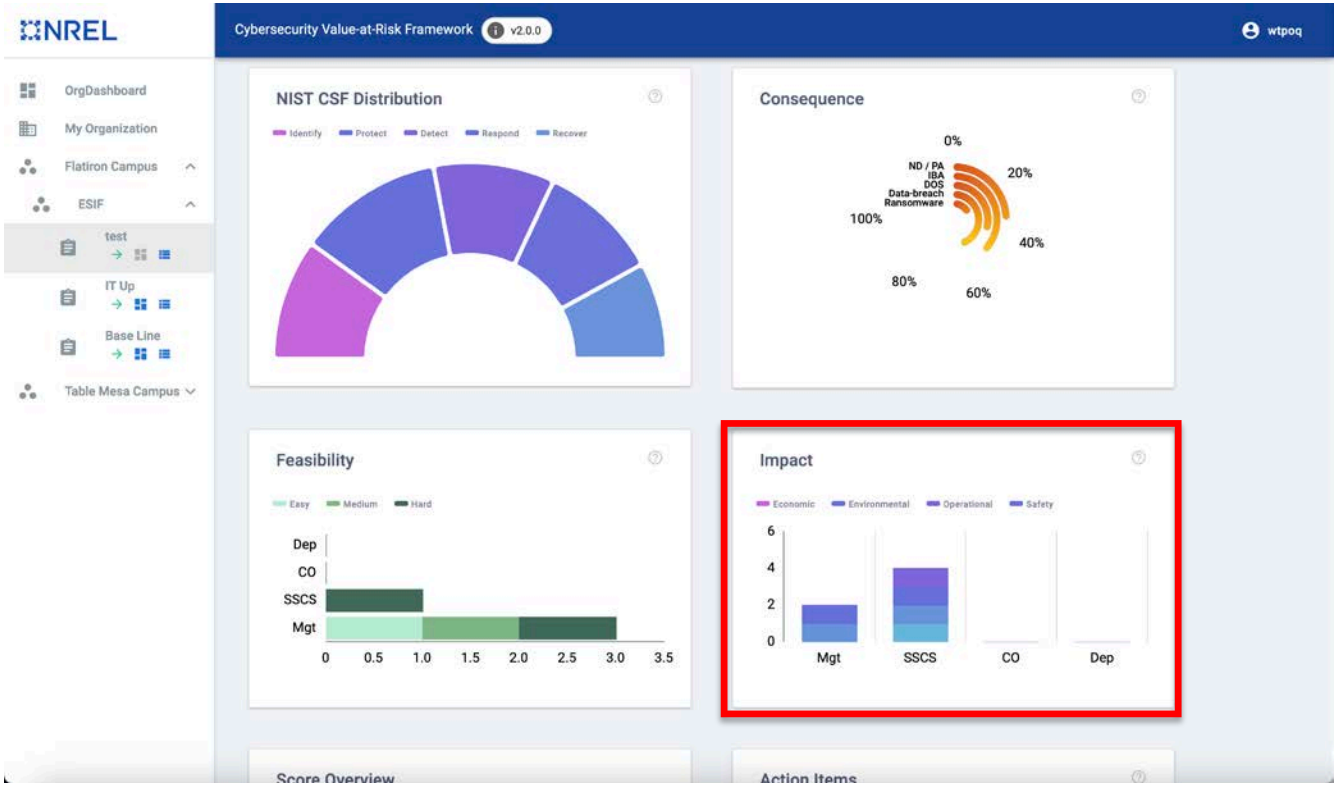
Consequence



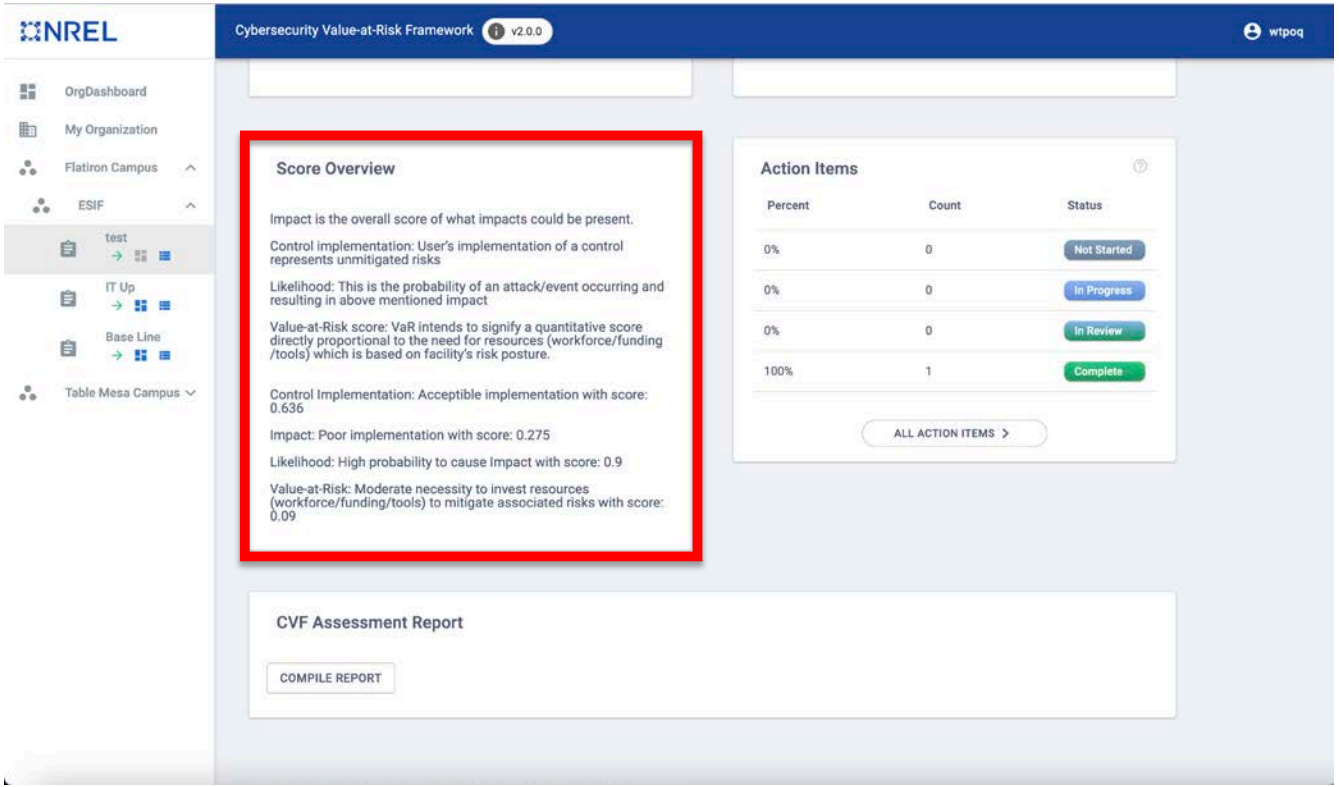
Feasibility



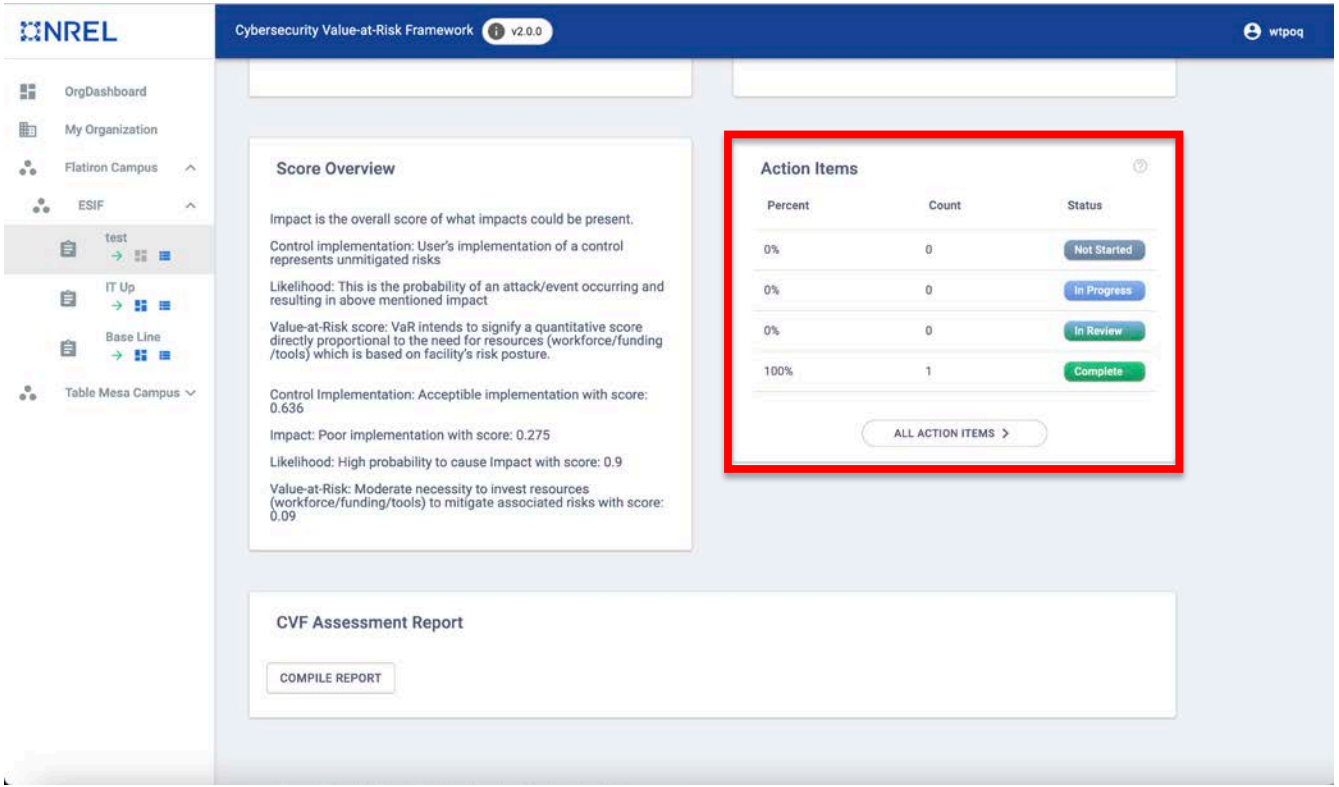
Impact


NREL
Cybersecurity Value-at-Risk Framework
v2.0.0
wtpoq
OrgDashboard
My Organization
Flatiron Campus
ESIF
test
IT Up
Base Line
Table Mesa Campus
NIST CSF Distribution
Identify
Protect
Detect
Respond
Recover
Consequence
0%
20%
40%
60%
80%
100%
ND / PA
IBA
DOS
Data-breach
Ransomware
Feasibility
Easy
Medium
Hard
Dep
CO
SSCS
Mgt
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Impact
Economic
Environmental
Operational
Safety
6
4
2
0
Mgt
SSCS
CO
Dep
Score Overview
Action Items

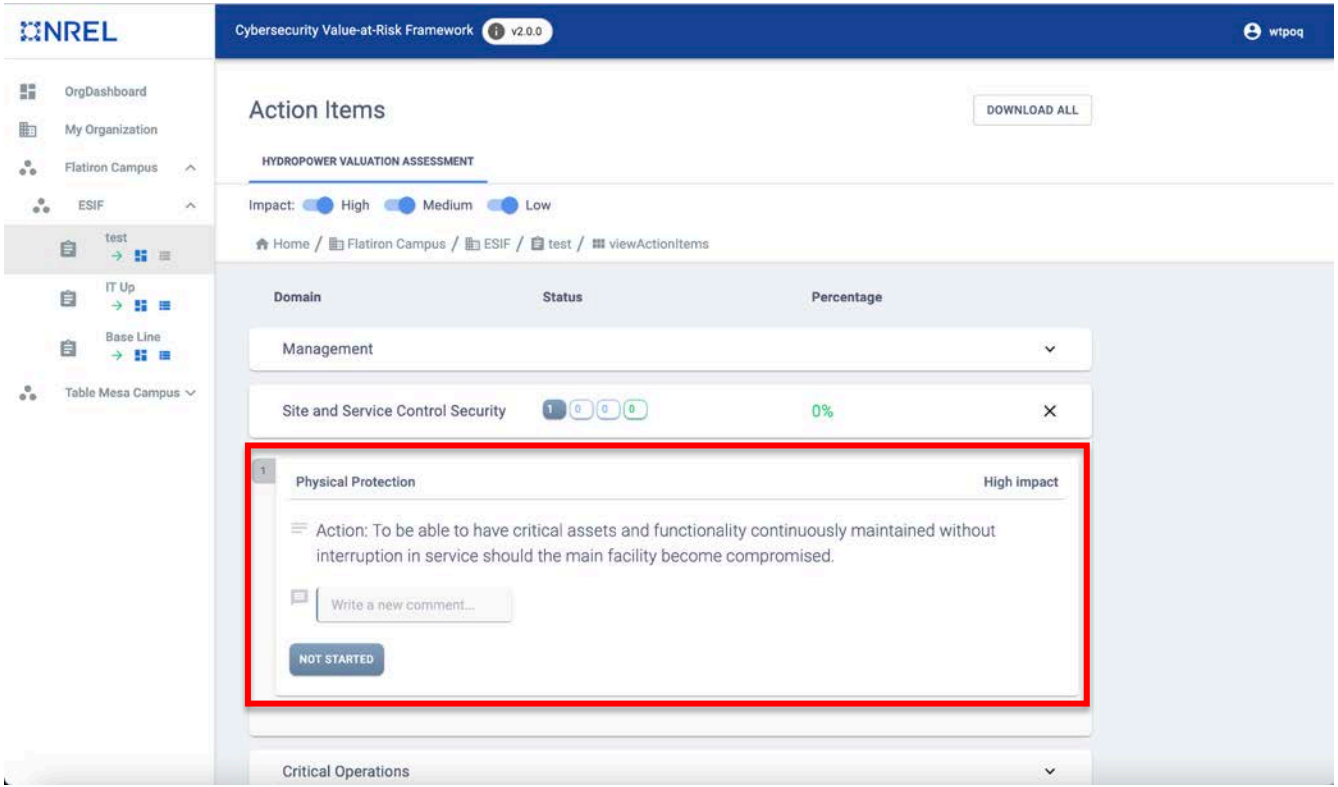
Scores Overview



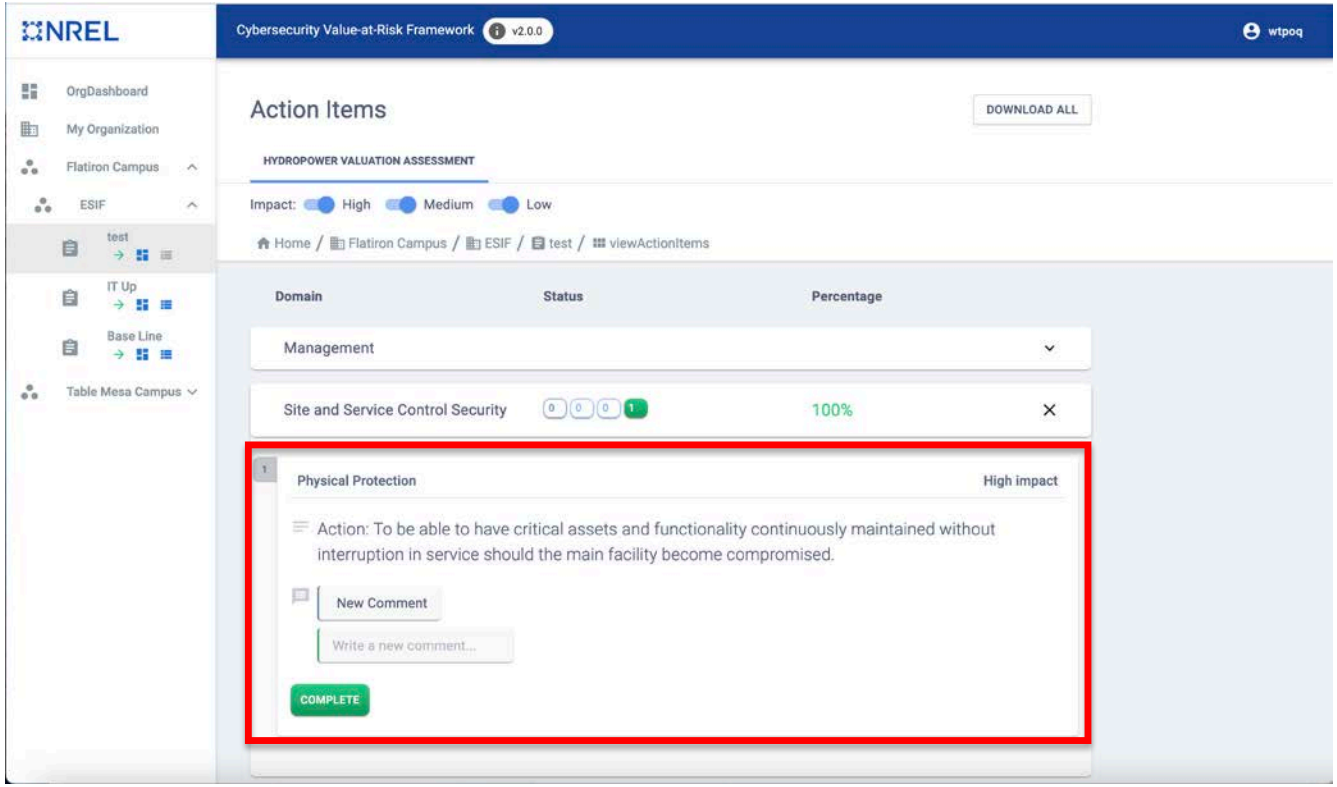
Action Items



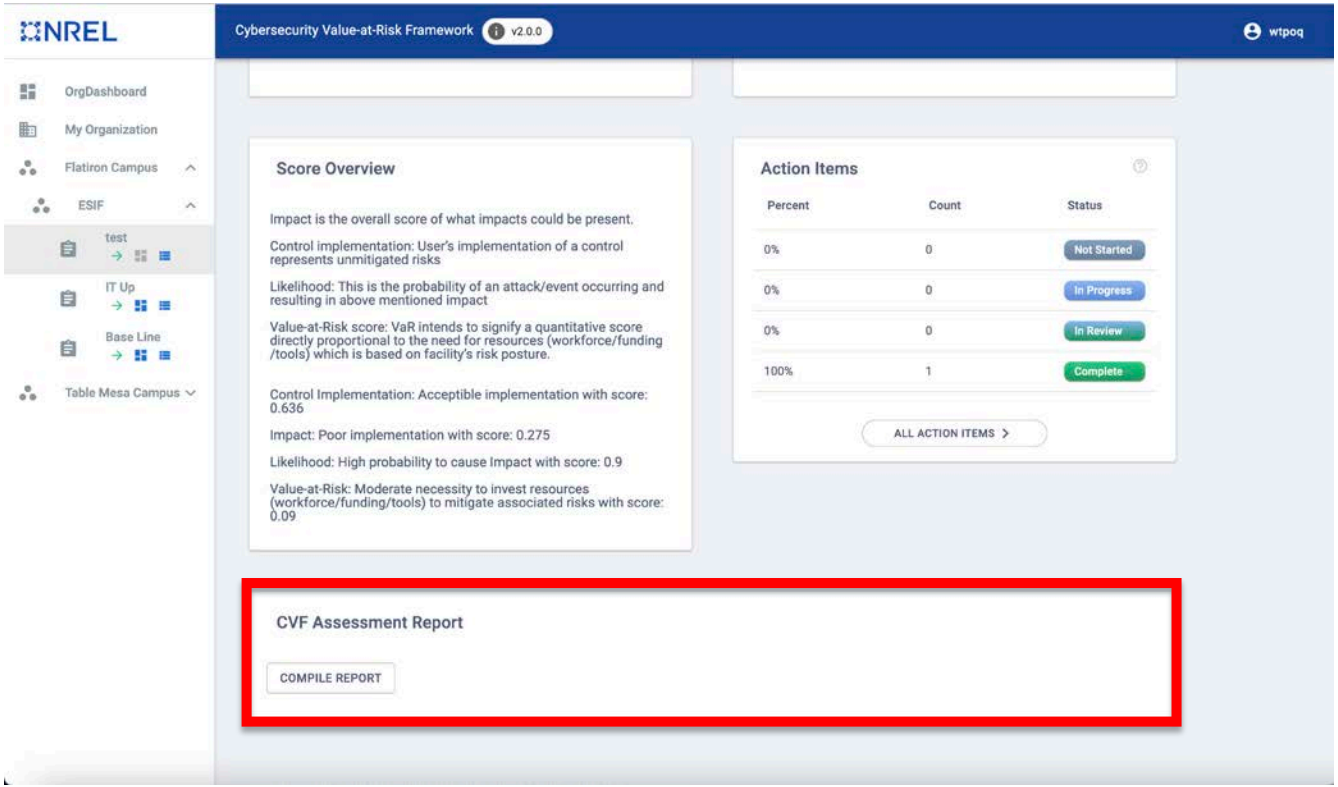
Actions Items



Actions Items



Report Widget



Assessment Report

Executive Summary

The National Renewable Energy Laboratory (NREL) developed the Hydropower Cybersecurity Value-at-Risk Framework (CVF) and web application. The web-based tool assists the facility's energy management team by walking the user through an assessment framework and bringing guidance and structure to the extensive array of cybersecurity controls applicable to hydropower plant resources. The assessment covers several domains containing multiple layers that address key cybersecurity topics and create a robust and flexible framework specifically designed for the hydropower fleet. domains containing multiple layers that address key cybersecurity topics and create a robust and flexible framework specifically designed for the hydropower fleet.

This report summarizes a completed assessment and contains sensitive, detailed information regarding ESIF's cybersecurity posture according to the CVF. Additionally, the appendices of this document contain customized and prioritized recommendations to begin creating a more secure environment. This document should serve as an ongoing reference during the development and improvement of cybersecurity and investment practices.

Importance of Cybersecurity Assessment

scoring methodology. The rapid migration of the public and private sector to a digital economy has made the risk of cyber-attacks extremely high in recent years. The business continuity of an enterprise is now strongly dependent on the strength of its cybersecurity controls. cybersecurity awareness of its employees and contractors and standard business processes that minimize exposure to attacks. The cost to an organization for a cybersecurity incident on a critical hydropower system can include direct financial loss, physical damage, severe reputation impact, and even loss of life. These consequences influence other impact categories such as environmental, economic, safety, and operational. Hydropower plants face numerous challenges in making informed decisions in managing upgrades and maintaining systems to ensure continuity of operations. Regular cybersecurity assessments that enable a risk-based approach to allocating resources and improving the overall cybersecurity posture of the organization is paramount in ensuring the security and resiliency of hydropower facilities. CVF was built to enable a comprehensive and periodic cybersecurity risk assessment that informs investment decisions. The National Institute of Standards and Technology (NIST) frameworks serve as reference guides in building the CVF assessment structure as well as the scoring methodology.

The remainder of this report is organized to provide a high-level summary followed by more detailed analysis of weak points categorized by CVF assessment, as well as their domains and subdomains.

Results Summary

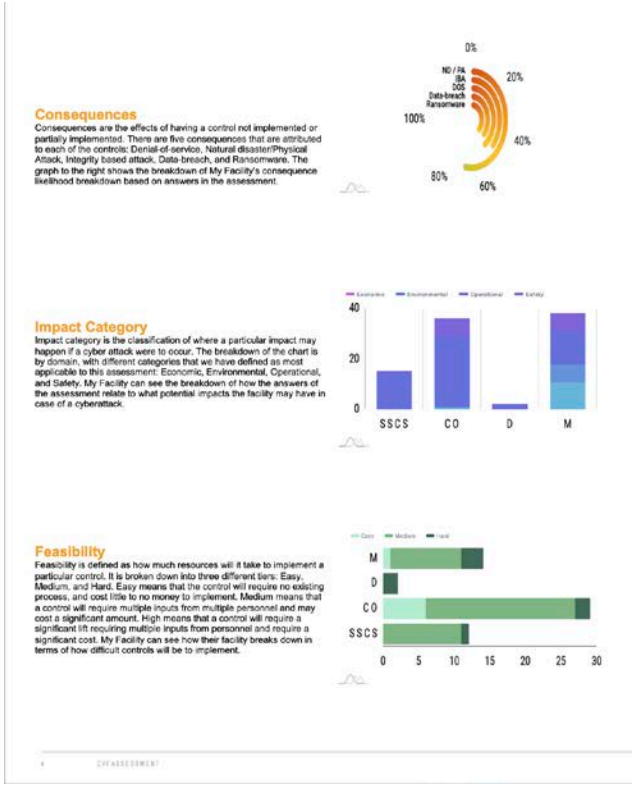
ESIF completed the cybersecurity valuation assessment on 2024/10/04. The Value-at-Risk score from the assessment was Moderate necessity to invest resources (workforce/funding/tools) to mitigate associated risks with score: 0.09. This score is calculated by the CVF application based on the collective responses from the ESIF representatives that participated in the assessment. This suggests that the ESIF cybersecurity Value-at-Risk (VaR) score is at a Moderate necessity to invest resources (workforce/funding/tools) to mitigate associated risks with score: 0.09 and there is opportunity for considerable improvement over the next 6-12 months across multiple domains if the actions described in Appendix B are completed. Below is a summary of the four posture levels based on VaR score (where lower scores are better):

- **Low:** The facility has a stronger posture with some room for improvements. There is a lower need to invest resources (workforce/funding/tools).
- **Moderate:** The facility has a good foundation in terms of cybersecurity practices. There is a moderate need to invest resources (workforce/funding/tools) and management should prioritize resource allocation accordingly to mitigate associated risks.
- **High:** A weak foundation in cybersecurity practices. There is a higher need to invest resources (workforce/funding/tools) and management should prioritize resource allocation accordingly to mitigate associated risks.
- **Extreme:** There are no cybersecurity practices in place. There is an extreme need to invest resources (workforce/funding/tools) and management should prioritize resource allocation accordingly to mitigate associated risks.

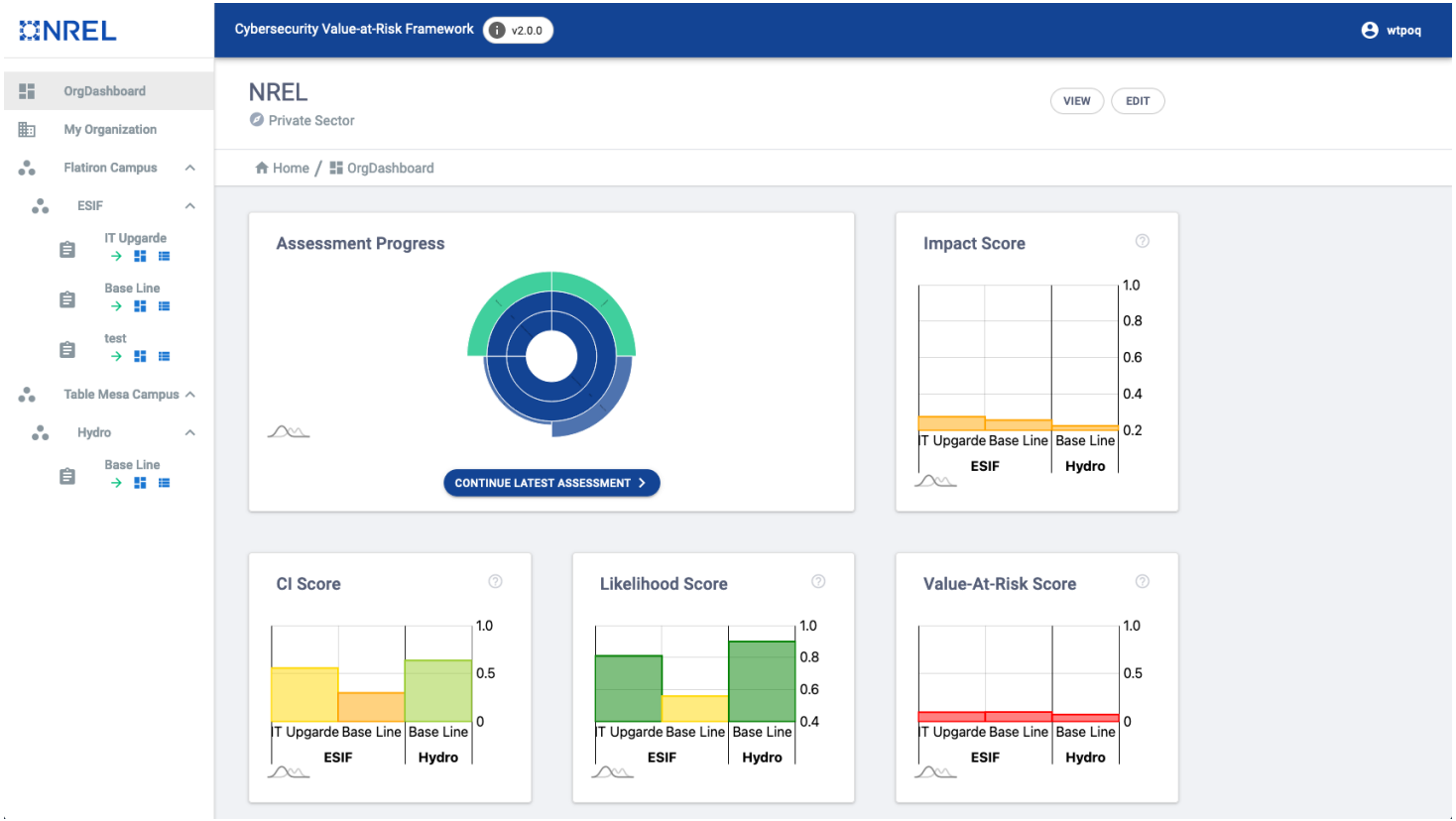
What is affecting my score?

It's critical to understand the immediate shortcomings of your cybersecurity score. This is caused by a combination of unanswered questions, which inhibit the potential to score points, and weak answers to questions with a high impact. Impact is defined as the importance a particular control has the rest of your security posture, and are categorized by low, medium, or high. Medium and high impact designated controls will have a greater impact on your score if not implemented.

Assessment Report



OrgDashboard



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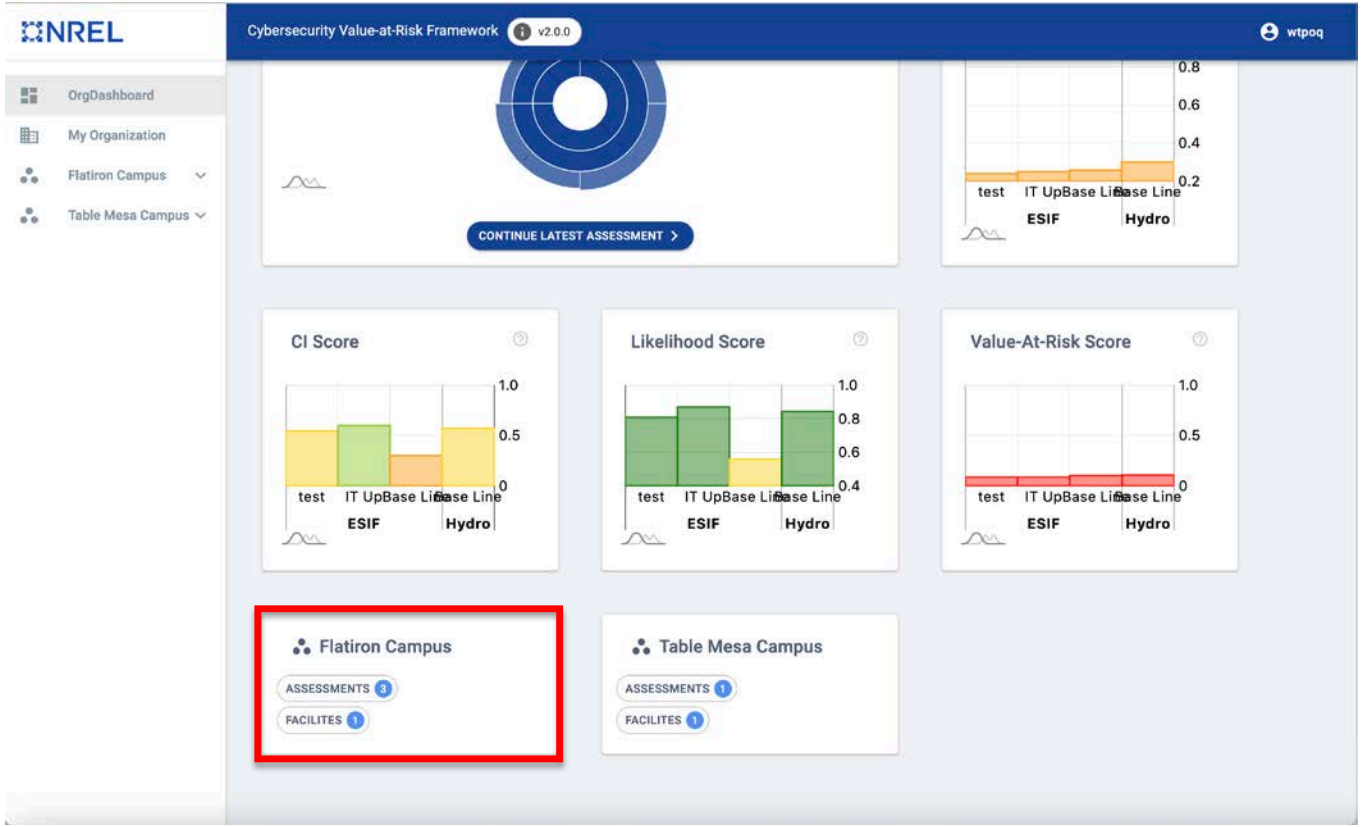
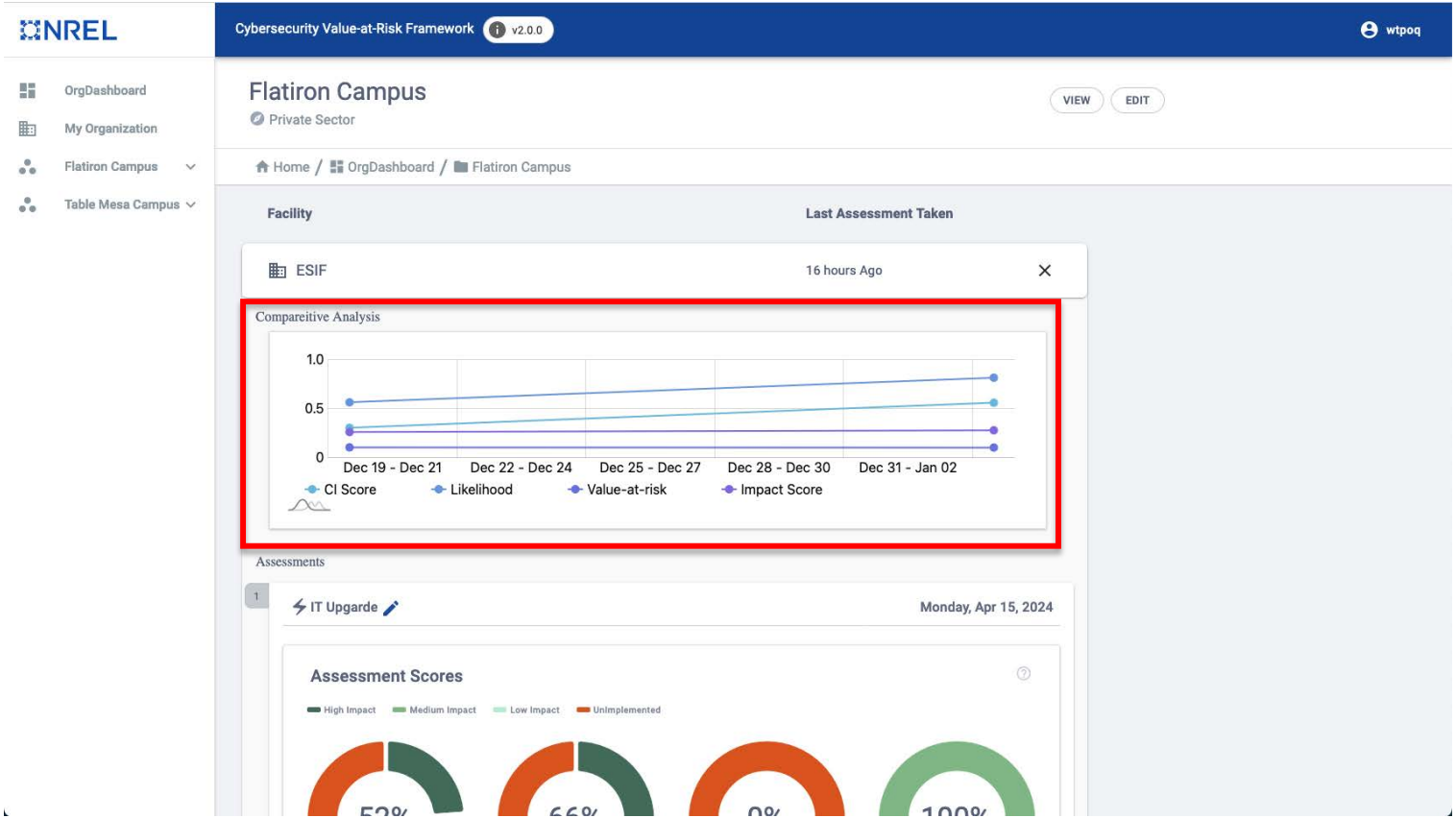
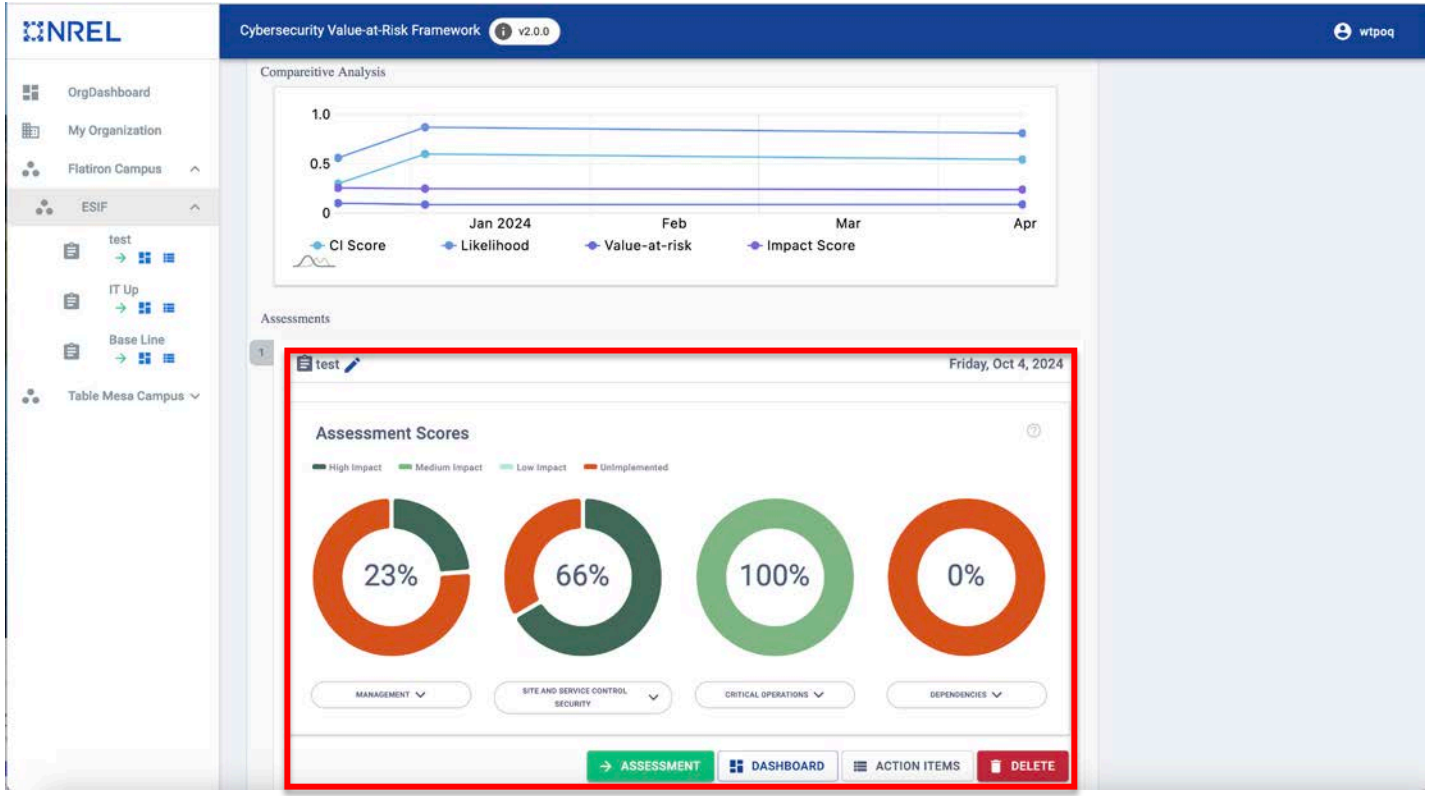


Comparative Analysis



Collection View



Future Work

- Advancements through Hydropower operational threat simulation and impact analysis
- Cost-benefit analysis for recommended mitigations with regards to potential cyber-attack consequences
- Monetary impact calculations for risks as well as mitigations

Q&A

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