

Mellow Multi Vault

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1. Project brief



Title	Description
Client	Mellow
Project name	Mellow Multi Vault
Timeline	06-01-2025 - 31-01-2025

Project Log

Date	Commit Hash	Note
10-01-2025	733df8430261584a7bfb53fcd5ce9d11b4e7123a	Initial Commit
13-01-2025	1876687cd64e6269494de3264eefa97909e8b2e5	New commit with fixes
30-01-2025	84a28875947006a5aa0f17d83d9e19faec6f354c	Reaudit
16-02-2025	65ce8dde861678f5d00bd3ac5bd458a4bf523f7f	Reaudit with Migrator and library bump

Short Overview

Mellow LRT functions as an LRT constructor, enabling users to deploy and manage their LRTs securely. Key features include robust access control and strategic asset management through modules and strategies.

Mellow Multi Vault allows you to operate directly with multiple subvaults. A subvault is a code-level abstraction for interacting with different restaking platforms and ERC4626 tokens. To interact with the EigenLayer contract system, IsolatedVaults are used, which allow restaking into different strategies.

Project Scope

The audit covered the following files:

<u>EigenLayerFactoryHelper.sol</u>	Migrator.sol	ERC4626Adapter.sol
<u>EigenLayerAdapter.sol</u>	<u>EigenLayerWstETHAdapter.sol</u>	<u>IsolatedEigenLayerVault.sol</u>
<u>IsolatedEigenLayerVaultFactory.sol</u>	IsolatedEigenLayerWstETHVault.sol	<u>IsolatedEigenLayerWstETHVaultFactor</u>
<u>SymbioticAdapter.sol</u>	<u>EigenLayerWithdrawalQueue.sol</u>	<u>SymbioticWithdrawalQueue.sol</u>
RatiosStrategy.sol	<u>Claimer.sol</u>	<u>WhitelistedEthWrapper.sol</u>
MultiVault.sol	MultiVaultStorage.sol	

2. Finding severity breakdown



All vulnerabilities discovered during the audit are classified based on their potential severity and have the following classification:

Severity	Description
Critical	Bugs leading to assets theft, fund access locking, or any other loss of funds to be transferred to any party.
High	Bugs that can trigger a contract failure. Further recovery is possible only by manual modification of the contract state or replacement.
Medium	Bugs that can break the intended contract logic or expose it to DoS attacks, but do not cause direct loss of funds.
Informational	Bugs that do not have a significant immediate impact and could be easily fixed.

Based on the feedback received from the Client regarding the list of findings discovered by the Contractor, they are assigned the following statuses:

Status	Description
Fixed	Recommended fixes have been made to the project code and no longer affect its security.
Acknowledged	The Client is aware of the finding. Recommendations for the finding are planned to be resolved in the future.

3. Summary of findings



Severity	# of Findings
Critical	1 (1 fixed, 0 acknowledged)
High	2 (2 fixed, 0 acknowledged)
Medium	5 (5 fixed, 0 acknowledged)
Informational	14 (6 fixed, 8 acknowledged)
Total	22 (14 fixed, 8 acknowledged)

4. Conclusion



During the audit of the codebase, 22 issues were found in total:

- 1 critical severity issue (1 fixed)
- 2 high severity issues (2 fixed)
- 5 medium severity issues (5 fixed)
- 14 informational severity issues (6 fixed, 8 acknowledged)

The final reviewed commit is 65ce8dde861678f5d00bd3ac5bd458a4bf523f7f

Deployment

Contract	Address
WhitelistedEthWrapper	0xfD4a4922d1AFe70000Ce0Ec6806454e78256504e
RatiosStrategy	0x3aA61E6196fb3eb1170E578ad924898624f54ad6
MultiVault (Implementation)	0x0C5BC4C8406Fe03214D18bbf2962Ae2fa378c6f7
SymbioticWithdrawalQueue (Implementation)	0xaB253B304B0BfBe38Ef7EA1f086D01A6cE1c5028
Migrator	0x37BE38A8Bd5D84DeFA072fFf6c0E1d923e9563EB

5. Findings report



CRITICAL-01

Funds locked in EigenLayerWithdrawalQueue due to incomplete

EigenLayerWithdrawalQueue.claimableAssetsOf() accounting

Fixed at: 9e2032c

Description

Line: EigenLayerWithdrawalQueue.sol#L75

The EigenLayerWithdrawalQueue.claimableAssetsOf() does not take into account accountData_.claimableAssets. That is, after EigenLayerWithdrawalQueue.handleWithdrawals() is called and assets moved into

_accountData[account].claimableAssets, the function will return zero, despite the fact that the remaining funds can still be claimed.

Impact: RatiosStrategy contract calls the EigenLayerWithdrawalQueue.claimableAssetsOf() to calculate withdrawal amounts. But the queue will account assets only from WithdrawalData and the remaining part from

_accountData[account].claimableAssets will be locked on the EigenLayerWithdrawalQueue contract.

Since the current implementation of the MultiVault contract does not support calling the

EigenLayerWithdrawalQueue.claim() function directly, the remaining funds will no longer be claimable.

This vulnerability is not critical for the user, as he can call the **EigenLayerWithdrawalQueue.claim()** from the queue himself, bypassing the **EigenLayerWithdrawalQueue.claimableAssetsOf()** function.

Recommendation

We recommend accounting _accountData[account].claimableAssets in EigenLayerWithdrawalQueue.claimableAssetsOf().

HIGH-01

Broken deposit functionality in IsolatedEigenLayerVault

Fixed at: <u>d11e531</u>

Description

Line: IsolatedEigenLayerVault.sol#L40

When depositing into **MultiVault**, after receiving data from the strategy, the deposit amount is distributed across the subvaults. Depending on the subvault type, the corresponding adapter's logic is invoked via **delegateCall**. In the **EigenLayerAdapter**, an allowance is granted to the **IsolatedEigenLayerVault** during the deposit call, followed by a call to its respective function at <u>Lines 124–125</u>. Within the deposit function of the **IsolatedEigenLayerVault**, a direct call is made to the **StrategyManager**. This call will revert because **safeTransferFrom** is not invoked beforehand, resulting in the balance of **IsolatedEigenLayerVault** always remaining zero.

Recommendation

We recommend transferring funds from MultiVault to IsolatedEigenLayerVault before interacting with StrategyManager.

HIGH-02

Funds will be stuck if the operator undelegated the staker

Fixed at: 9e2032c

Description

DelegationManager allows the operator to undelegate the staker. If the operator calls **DelegationManager.undelegate()**, the shares delegated to the operator will be queued for withdrawal to the staker address. In this case withdrawal happened outside of **EigenLayerWithdrawalQueue** and this withdrawal will not be handled. Due to **EigenLayerWithdrawalQueue** will not have this withdrawal request there will be no way to claim assets from EigenLayer.

Impact: assets of **IsolatedVault** will stuck in the EigenLayer, calculations in **MultiVault.totalAssets()** will be incorrect.

Recommendation

We recommend adding implementation to handle cases when request withdrawal happens outside of **EigenLayerWithdrawalQueue**. For example, using **EigenLayerAdapter.claimWithdrawal()**.

MEDIUM-01

Missing access control in the IsolatedEigenLayerVault.delegateTo() function

Fixed at: 9e2032c

Description

Line: <u>IsolatedEigenLayerVault.sol#L25</u>

When the factory creates IsolatedEigenLayerVault in the IsolatedEigenLayerVaultFactory.sol#L42 contract, it calls IsolatedEigenLayerVault.delegateTo(). This function doesn't have access control and anyone can call it. EigenLayer doesn't allow to call DelegationManager.delegateTo() again if the staker already delegated shares. But the delegated operator can call DelegationManager.undelegate() and then anyone can call IsolatedEigenLayerVault.delegateTo() and delegate the vault's shares to the wrong operator.

Impact: The vault's shares will be delegated to the wrong operator who can commit illegal acts.

Recommendation

We recommend adding an access check in the **IsolatedEigenLayerVault.delegateTo()** function:

require(msg.sender == factory)

MEDIUM-02

Missing memory allocation in

EigenLayerWithdrawalQueue.transferedWithdrawalsOf()

Fixed at:

9e2032c

Description

Line: EigenLayerWithdrawalQueue.sol#L100

The function declares a return value **uint256[] memory withdrawals** but never allocates memory for this array. When the function tries to write to **withdrawals[i]** in the loop, it will cause a revert: index out of bounds.

Recommendation

We recommend allocating memory for the return value.

```
function transferedWithdrawalsOf(address account, uint256 limit, uint256 offset)
  public
  view
  returns (uint256[] memory withdrawals)
{
    ...
    uint256 count = (length - offset).min(limit);
    withdrawals = new uint256[](count); // allocation
    for (uint256 i = 0; i < count; i++) {
        withdrawals[i] = transferedWithdrawals.at(i + offset);
    }
}</pre>
```

MEDIUM-03

Wrong manager contract in EigenLayerAdapter.areWithdrawalsPaused()

<u>9e2032c</u>

Description

Line: EigenLayerAdapter.sol#L143

In the **EigenLayerAdapter.areWithdrawalsPaused()** function, the wrong contract is checked for a pause. The function is using **strategyManager** when it should be using **delegationManager** to check the withdrawal queue pause state. **PAUSED_ENTER_WITHDRAWAL_QUEUE** and **PAUSED_EXIT_WITHDRAWAL_QUEUE** operations are managed by the

DelegationManager contract, not the **StrategyManager**.

Impact: This could lead to withdrawals being allowed when they should be paused or vice versa.

Recommendation

We recommend calling **DelegationManager** contract instead of **StrategyManager**.

```
- IPausable manager = IPausable(address(strategyManager));
```

+ IPausable manager = IPausable(address(delegationManager));

MEDIUM-04

The function IsolatedEigenLayerVaultFactory.getOrCreate() can't be called twice

Fixed at:

9e2032c

Description

Lines: <u>IsolatedEigenLayerVaultFactory.sol#L33-L37</u>

At the beginning of the function **IsolatedEigenLayerVaultFactory.getOrCreate()**, it checks if a corresponding **isolatedVault** has been already created and returns its Withdrawal queue:

```
bytes32 key_ = key(owner, strategy, operator);
isolatedVault = isolatedVaults[key_];
if (isolatedVault != address(0)) {
   return (isolatedVault, instances[isolatedVault].withdrawalQueue);
}
```

If it hasn't the function creates a new vault and queue.

After that, it should have added the new vault and queue the **isolatedVaults** mapping to return it the next time the function is called with the same parameters. The second call will lead to an error instead because it will try to create **IsolatedEigenLayerVault** at the same address where it already exists.

Recommendation

We recommend saving the vault and its corresponding queue to the storage.

MEDIUM-05

MAX_CLAIMING_WITHDRAWALS limit accounting Inconsistency

Fixed at:

84a2887

Description

Line: EigenLayerWithdrawalQueue.sol#L193

Problem scenario:

- 1. MultiVault has 6 claimable withdrawals
- 2. EigenLayerWithdrawalQueue.claimableAssetsOf() and EigenLayerWithdrawalQueue.pendingAssetsOf() would be calculated based on: the first 5 as "claimable" and 6th as "pending"
- 3. We call MultiVault.withdraw() and via MultiVault._withdraw() call EigenLayerWithdrawalQueue.claim() and EigenLayerWithdrawalQueue.transferPendingAssets() consequently
- 4. First handleWithdrawals() call processes 5 withdrawals in EigenLayerWithdrawalQueue.claim()
- 5. Second handleWithdrawals() call processes the last withdrawal in

EigenLayerWithdrawalQueue.transferPendingAssets() and convert **pendingAssets** into **claimableAssets**. Now we have 0 pending withdrawals and a non-zero amount for transfer

6. Transaction reverts with revert("EigenLayerWithdrawalQueue: insufficient pending assets")

Recommendation

We recommend reconsidering logic when the claimable withdrawal[i] is considered pending due to

i > MAX_CLAIMING_WITHDRAWALS or changing call order in MultiVault._withdraw():

```
Subvault memory subvault = subvaultAt(subvaultIndex);
address this_ = address(this);
if (pending != 0) {
    IWithdrawalQueue(subvault.withdrawalQueue).transferPendingAssets(receiver, pending);
}
if (claimable != 0) {
    IWithdrawalQueue(subvault.withdrawalQueue).claim(this_, receiver, claimable);
}
```



Description

Lines:

- MultiVault.sol#L150
- MultiVault.sol#L156
- MultiVault.sol#L162

The only restriction when setting adapters for different protocols is the restriction on **msg.sender**—it must have the **SET_ADAPTER_ROLE**. There are no checks inside the setters, which means that it can add adapters configured for another vault.

Recommendation

We recommend adding sanity checks in setter functions for adapters to ensure that the vault address in the adapter is the MultiVault address.

INFORMATIONAL-02

Wrong value is passed to Transfer event in SymbioticWithdrawalQueue

Fixed at: d11e531

Description

Line: SymbioticWithdrawalQueue.sol#L145

In the if condition at <u>Lines 141–145</u> shares from the **nextEpoch** are transferred. In the **Transfer** event **nextPending** value is passed for the **amount** field, but the **nextPending** is the actual amount of assets that were transferred not the withdrawal queue shares.

Recommendation

We recommend passing the nextSharesToClaim value for the amount field of the Transfer event.



Description

Lines:

- MultiVault.sol#L236
- MultiVault.sol#L323
- EigenLayerWithdrawalQueue.sol#L97
- <u>IsolatedEigenLayerVault.sol#L62</u>
- 1. All calculations performed with **curatorFee** are necessary only If **data.curatorFeeD6** doesn't equal zero. If it is zero, then **curatorFee** will be zero and won't affect further calculations.
- 2. At <u>Line 323</u> where **data[i].deposit** is subtracted from the variable **assets**, the value of **assets** is neither used nor returned afterward. As a result, this subtraction is a waste of gas and serves no purpose.
- 3. The **transferedWithdrawalsOf** function is declared as **public**, but it is not called within the **EigenLayerWithdrawalQueue** contract itself. Therefore, to save gas, it can be declared as **external**.
- 4. In the RewardsCoordinator function processClaim(), the second parameter specifies the recipient's address. In IsolatedEigenLayerVault, the recipient address is set to address(this), meaning the rewards are first transferred to the IsolatedEigenLayerVault and then forwarded to the MultiVault. This adds an unnecessary transfer since the processClaim() function can only be called by the MultiVault, which already has a mechanism to check the number of transferred assets. To optimize this process the recipient address in processClaim should be directly set to the MultiVault address instead of address(this) in the IsolatedEigenLayerVault.

Recommendation

We recommend accounting for curatorFee only if data.curatorFeeD6 equals zero.

```
if (data.curatorFeeD6 != 0) {
    uint256 curatorFee = rewardAmount.mulDiv(data.curatorFeeD6, D6);
    rewardAmount = rewardAmount - curatorFee;

    rewardToken.safeTransfer(data.curatorTreasury, curatorFee);
}
...
```

Also, we recommended resolving all other gas optimisation issues

INFORMATIONAL-04

Subvault removing may cause blocking of staked funds

Acknowledged

Description

Line: MultiVault.sol#L97

The function for removing a subvault from the set in **MultiVault** is restricted and can only be called by the role **REMOVE_SUBVAULT_ROLE**. In the internal function **_removeSubvault**, data is simply deleted from the array and the mapping. However, there are no checks to ensure that there is no active stake in the given subvault. This could lead to a situation where, due to careless or malicious removal, MultiVault's funds could become stuck in the subvault, as it will no longer be possible to make a withdrawal request after removal.

Recommendation

We recommend adding a sanity check when removing a subvault, that **MultiVault** doesn't have an active stake in this subvault or making a withdrawal of this stake before removal.



INFORMATIONAL-05

Unused function in EigenLayerAdapter

Fixed at: 9e2032c

Description

Line: EigenLayerAdapter.sol#L129

Function **EigenLayerAdapter.claimWithdrawal()** can be invoked via **delegateCall** and from **MultiVault**. However, there is no logic in **MultiVault** to call this function. Additionally, within this function, it calls **IsolatedEigenLayerVault.claimWithdrawal()**, but this function can only be invoked by the **EigenLayerWithdrawalQueue**. Consequently, the call will revert.

Recommendation

We recommend adding possibility to call this function from MultiVault contract to handle unexpected withdrawals.

INFORMATIONAL-06

Code refactor for withdrawal process from EigenLayer strategy

Acknowledged

Description

Line: EigenLayerAdapter.sol#L109

During the withdrawal process, the adapter calls the **withdraw()** function in **IsolatedEigenLayerVault**, which in turn internally calls the **request()** function in **EigenLayerWithdrawalQueue**. Within this function, the required **calldata** is generated, and it calls back to **IsolatedEigenLayerVault** at <u>Line 138</u>. This approach is gas-intensive, complicates the logic, and increases the risk of unpredictable behavior.

Instead, the parameters for the **delegationManager**'s function calls can be formed directly within the

IsolatedEigenLayerVault. When calling withdraw in IsolatedEigenLayerVault, the process can be optimized as follows:

- 1. Generate the parameters for the queueWithdrawals() function and call it in the delegationManager.
- 2. Call **request** in **WithdrawalQueue** and make the necessary changes only to the state of the queue. This approach eliminates reentrancy during calls between **IsolatedEigenLayerVault** and **WithdrawalQueue**, reduces the risk of unpredictable behavior, and optimizes gas costs.

Recommendation

We recommend refactoring the code to eliminate reentrancy calls and remove excessive logic from the **EigenLayerWithdrawalQueue**.

INFORMATIONAL-07

delegationApprover should know address of IsolatedEigenLayerVault before its creation

Fixed at: 84a2887

Description

Line: IsolatedEigenLayerVaultFactory.sol#L42

When creating an **IsolatedEigenLayerVault**, along with the addresses of the operator, strategy, and owner, a special signature from the **delegationApprover** is also provided. Immediately after the **Vault** is created, the **delegateTo()** function in the **delegationManager** is called. This function receives the provided signature, which is validated if the operator has a configured **delegationApprover**.

The **delegationApprover** signs the addresses of the staker, operator, and salt, thereby authorizing the staker to delegate for a specific operator. However, to generate this signature, the delegationApprover must know the address of the IsolatedEigenLayerVault being created.

Recommendation

We recommend adding a view function that returns the address of the planned IsolatedEigenLayerVault.



INFORMATIONAL-08

Missing events in EigenLayer contracts

Fixed at: 9e2032c

Description

None of EigenLayer's contracts includes any **events**, which makes it challenging for off-chain observers and other services to efficiently track actions and interactions.

Recommendation

We recommend introducing relevant events in functions to improve transparency and enable better monitoring.

INFORMATIONAL-09

The return value from EigenLayerWithdrawalQueue._pull() is not used

Fixed at: 84a2887

Description

Line: EigenLayerWithdrawalQueue.sol#L258

The function **EigenLayerWithdrawalQueue._pull()** returns a **bool** value, which is not used anywhere.

Recommendation

We recommend removing the returned value.

INFORMATIONAL-10

Gas optimization in the

EigenLayerWithdrawalQueue.transferPendingAssets() function

Fixed at:

84a2887

Description

Line: EigenLayerWithdrawalQueue.sol#L179

If accountAssets == amount then we should remove withdrawalIndex from accountData_.withdrawals, change balances and exit the loop, but we don't exit the loop. This will waste more gas.

Recommendation

We recommend adding extra condition:

```
if (accountAssets <= amount) {
    delete balances[from];
    balances[to] += accountShares;
    accountData_.withdrawals.remove(withdrawalIndex);
    amount -= accountAssets;
    if (amount == 0) {
        return;
    }
    pendingWithdrawals--;
} else {
    uint256 shares_ = accountShares.mulDiv(amount, accountAssets);
    balances[from] -= shares_;
    balances[to] += shares_;
    return;
}</pre>
```



Description

Lines:

SymbioticWithdrawalQueue.sol#L217 - If claimEpoch is zero, no claims are made for claimEpoch - 1.

MultiVault.sol#L370 - // emitting event with transferred + new pending assets

<u>IsolatedEigenLayerVault.sol#L56</u> - **IRewardsCoordinator coordinator**

Typo in parameter name receiver:

- EigenLayerAdapter.sol#L112
- ERC4626Adapter.sol#L52
- <u>IsolatedEigenLayerWstETHVault.sol#L36</u>

Typo in the word transferred:

- <u>EigenLayerWithdrawalQueue.sol#L97</u>
- EigenLayerWithdrawalQueue.sol#L103
- <u>EigenLayerWithdrawalQueue.sol#L153</u>
- <u>EigenLayerWithdrawalQueue.sol#L177</u>
- <u>EigenLayerWithdrawalQueue.sol#L242</u>
- <u>EigenLayerWithdrawalQueue.sol#L245</u>
- <u>EigenLayerWithdrawalQueue.sol#L299</u>

Recommendation

We recommend correcting the typos.

INFORMATIONAL-12

Gas optimizations in the EigenLayerWithdrawalQueue contract

Acknowledged

Description

Lines:

- <u>EigenLayerWithdrawalQueue.sol#L58</u>
- EigenLayerWithdrawalQueue.sol#L75
- <u>EigenLayerWithdrawalQueue.sol#L277</u>

The **EigenLayerWithdrawalQueue** contract contains functions that iterate through **AccountData.withdrawals** values. It can be done more efficiently by accessing the elements directly by the index in the set.

Recommendation

To save gas, we recommend changing the **AccountData.withdrawals** reading method to an index reference.



INFORMATIONAL-13

Extra check in the function

EigenLayerWithdrawalQueue.transferPendingAssets()

Acknowledged

Description

Lines:

- EigenLayerWithdrawalQueue.sol#L216
- <u>EigenLayerWithdrawalQueue.sol#L203</u>
- <u>EigenLayerWithdrawalQueue.sol#L283-L290</u>

The function **EigenLayerWithdrawalQueue.transferPendingAssets()** checks if an account's **withdrawal** has the **isClaimed** flag set to **true** but all **withdrawal**s of the account marked as claimed have been removed by calling the function **handleWithdrawals()**. Therefore, this check may be removed to save the gas.

Recommendation

We recommend considering all account's withdrawal as not claimed.

INFORMATIONAL-14

Unbounded migration delay parameter

Acknowledged

Description

Line: Migrator.sol#L26

The **migrationDelay** parameter in the Migrator contract's constructor lacks bounds checking. Big values can lock vaults migration indefinitely, and very small values might not provide enough time to cancel the migration.

Recommendation

We recommend adding validation checks in the constructor to ensure the migrationDelay parameter falls within reasonable bounds:

```
constructor(
   address simpleLrtFactory_,
   address previousMigrator_,
   address multiVaultSingleton_,
   address strategy_,
   address symbioticVaultFactory_,
   address withdrawalQueueSingleton_,
   uint256 migrationDelay_
) {
    // ... the rest of the code
   migrationDelay = migrationDelay_;
   require(migrationDelay_ >= 1 days && migrationDelay_ <= 30 days, "Migrator: delay out of bounds");
}</pre>
```

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