



# SMART CONTRACT AUDIT REPORT

for

## Magpie Protocol



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# 1 | Introduction

Given the opportunity to review the design document and related smart contract source code of the `Magpie` protocol, we outline in the report our systematic approach to evaluate potential security issues in the smart contract implementation, expose possible semantic inconsistencies between smart contract code and design document, and provide additional suggestions or recommendations for improvement. Our results show that the given version of smart contracts can be further improved due to the presence of several issues related to either security or performance. This document outlines our audit results.

## 1.1 About Magpie Protocol

`Magpie` is an innovative yield-boosting protocol that provides users with boosted stablecoin yields from the innovative stableswap platform – `Wombat Exchange`, without even having to hold the `WOM` token. Conversely, `WOM` holders can also benefit from `Magpie` by converting their `WOM` token into `mWOM` (`Magpie WOM`) to earn a share of `Magpie`'s profit. `Magpie` implements the `Magpie` token (`MGP`) for the protocol management, which is deployed at address `0xD06716E1Ff2E492Cc5034c2E81805562dd3b45fa`. The basic information of the audited protocol is as follows:

Table 1.1: Basic Information of The `Magpie` Protocol

Item	Description
Issuer	<code>Magpie</code>
Website	<a href="https://www.magpies.xyz/">https://www.magpies.xyz/</a>
Type	EVM Smart Contract
Platform	Solidity
Audit Method	Whitebox
Latest Audit Report	October 20, 2022

In the following, we show the Git repository of reviewed files and the commit hash values used in the audit.

- [https://github.com/magpiexyz/magpie\\_contracts.git](https://github.com/magpiexyz/magpie_contracts.git) (4ada7e9, e59e4b0)

And here are the commit IDs after all fixes for the issues found in the audit have been checked in:

- [https://github.com/magpiexyz/magpie\\_contracts.git](https://github.com/magpiexyz/magpie_contracts.git) (23ba731, 27f5fba)

## 1.2 About PeckShield

PeckShield Inc. [9] is a leading blockchain security company with the goal of elevating the security, privacy, and usability of current blockchain ecosystems by offering top-notch, industry-leading services and products (including the service of smart contract auditing). We are reachable at Telegram (<https://t.me/peckshield>), Twitter (<http://twitter.com/peckshield>), or Email ([contact@peckshield.com](mailto:contact@peckshield.com)).

Table 1.2: Vulnerability Severity Classification

Impact	High	Critical	High	Medium
	Medium	High	Medium	Low
	Low	Medium	Low	Low
		High	Medium	Low
		Likelihood		

## 1.3 Methodology

To standardize the evaluation, we define the following terminology based on OWASP Risk Rating Methodology [8]:

- Likelihood represents how likely a particular vulnerability is to be uncovered and exploited in the wild;
- Impact measures the technical loss and business damage of a successful attack;
- Severity demonstrates the overall criticality of the risk.

Likelihood and impact are categorized into three ratings: *H*, *M* and *L*, i.e., *high*, *medium* and *low* respectively. Severity is determined by likelihood and impact and can be classified into four categories accordingly, i.e., *Critical*, *High*, *Medium*, *Low* shown in Table 1.2.

Table 1.3: The Full List of Check Items

Category	Check Item
Basic Coding Bugs	Constructor Mismatch
	Ownership Takeover
	Redundant Fallback Function
	Overflows & Underflows
	Reentrancy
	Money-Giving Bug
	Blackhole
	Unauthorized Self-Destruct
	Revert DoS
	Unchecked External Call
	Gasless Send
	Send Instead Of Transfer
	Costly Loop
	(Unsafe) Use Of Untrusted Libraries
	(Unsafe) Use Of Predictable Variables
	Transaction Ordering Dependence
	Deprecated Uses
Semantic Consistency Checks	Semantic Consistency Checks
Advanced DeFi Scrutiny	Business Logics Review
	Functionality Checks
	Authentication Management
	Access Control & Authorization
	Oracle Security
	Digital Asset Escrow
	Kill-Switch Mechanism
	Operation Trails & Event Generation
	ERC20 Idiosyncrasies Handling
	Frontend-Contract Integration
	Deployment Consistency
	Holistic Risk Management
Additional Recommendations	Avoiding Use of Variadic Byte Array
	Using Fixed Compiler Version
	Making Visibility Level Explicit
	Making Type Inference Explicit
	Adhering To Function Declaration Strictly
	Following Other Best Practices

To evaluate the risk, we go through a list of check items and each would be labeled with a severity category. For one check item, if our tool or analysis does not identify any issue, the contract is considered safe regarding the check item. For any discovered issue, we might further deploy contracts on our private testnet and run tests to confirm the findings. If necessary, we would additionally build a PoC to demonstrate the possibility of exploitation. The concrete list of check items is shown in Table 1.3.

In particular, we perform the audit according to the following procedure:

- Basic Coding Bugs: We first statically analyze given smart contracts with our proprietary static code analyzer for known coding bugs, and then manually verify (reject or confirm) all the issues found by our tool.
- Semantic Consistency Checks: We then manually check the logic of implemented smart contracts and compare with the description in the white paper.
- Advanced DeFi Scrutiny: We further review business logics, examine system operations, and place DeFi-related aspects under scrutiny to uncover possible pitfalls and/or bugs.
- Additional Recommendations: We also provide additional suggestions regarding the coding and development of smart contracts from the perspective of proven programming practices.

To better describe each issue we identified, we categorize the findings with Common Weakness Enumeration (CWE-699) [7], which is a community-developed list of software weakness types to better delineate and organize weaknesses around concepts frequently encountered in software development. Though some categories used in CWE-699 may not be relevant in smart contracts, we use the CWE categories in Table 1.4 to classify our findings.

## 1.4 Disclaimer

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Note that this security audit is not designed to replace functional tests required before any software release, and does not give any warranties on finding all possible security issues of the given smart contract(s) or blockchain software, i.e., the evaluation result does not guarantee the nonexistence of any further findings of security issues. As one audit-based assessment cannot be considered comprehensive, we always recommend proceeding with several independent audits and a public bug bounty program to ensure the security of smart contract(s). Last but not least, this security audit should not be used as investment advice.

Table 1.4: Common Weakness Enumeration (CWE) Classifications Used in This Audit

Category	Summary
<b>Configuration</b>	Weaknesses in this category are typically introduced during the configuration of the software.
<b>Data Processing Issues</b>	Weaknesses in this category are typically found in functionality that processes data.
<b>Numeric Errors</b>	Weaknesses in this category are related to improper calculation or conversion of numbers.
<b>Security Features</b>	Weaknesses in this category are concerned with topics like authentication, access control, confidentiality, cryptography, and privilege management. (Software security is not security software.)
<b>Time and State</b>	Weaknesses in this category are related to the improper management of time and state in an environment that supports simultaneous or near-simultaneous computation by multiple systems, processes, or threads.
<b>Error Conditions, Return Values, Status Codes</b>	Weaknesses in this category include weaknesses that occur if a function does not generate the correct return/status code, or if the application does not handle all possible return/status codes that could be generated by a function.
<b>Resource Management</b>	Weaknesses in this category are related to improper management of system resources.
<b>Behavioral Issues</b>	Weaknesses in this category are related to unexpected behaviors from code that an application uses.
<b>Business Logics</b>	Weaknesses in this category identify some of the underlying problems that commonly allow attackers to manipulate the business logic of an application. Errors in business logic can be devastating to an entire application.
<b>Initialization and Cleanup</b>	Weaknesses in this category occur in behaviors that are used for initialization and breakdown.
<b>Arguments and Parameters</b>	Weaknesses in this category are related to improper use of arguments or parameters within function calls.
<b>Expression Issues</b>	Weaknesses in this category are related to incorrectly written expressions within code.
<b>Coding Practices</b>	Weaknesses in this category are related to coding practices that are deemed unsafe and increase the chances that an exploitable vulnerability will be present in the application. They may not directly introduce a vulnerability, but indicate the product has not been carefully developed or maintained.



## 2 | Findings

### 2.1 Summary

Here is a summary of our findings after analyzing the `Maggie` protocol implementation. During the first phase of our audit, we study the smart contract source code and run our in-house static code analyzer through the codebase. The purpose here is to statically identify known coding bugs, and then manually verify (reject or confirm) issues reported by our tool. We further manually review business logics, examine system operations, and place DeFi-related aspects under scrutiny to uncover possible pitfalls and/or bugs.

Severity	# of Findings	
Critical	0	
High	2	■ ■
Medium	3	■ ■ ■
Low	2	■ ■
Informational	0	
Total	7	

We have so far identified a list of potential issues: some of them involve subtle corner cases that might not be previously thought of, while others refer to unusual interactions among multiple contracts. For each uncovered issue, we have therefore developed test cases for reasoning, reproduction, and/or verification. After further analysis and internal discussion, we determined a few issues of varying severities that need to be brought up and paid more attention to, which are categorized in the above table. More information can be found in the next subsection, and the detailed discussions of each of them are in [Section 3](#).

## 2.2 Key Findings

Overall, these smart contracts are well-designed and engineered, though the implementation can be improved by resolving the identified issues (shown in Table 2.1), including 2 high-severity vulnerabilities, 3 medium-severity vulnerabilities and 2 low-severity vulnerabilities.

Table 2.1: Key Magpie Protocol Audit Findings

ID	Severity	Title	Category	Status
PVE-001	Medium	Revisited Logic To Distribute Caller Fee	Business Logic	Fixed
PVE-002	High	Incorrect Token Flow in withdraw()	Business Logic	Fixed
PVE-003	Low	Improved Sanity Checks For Function Parameters	Coding Practices	Fixed
PVE-004	Medium	Trust Issue of Admin Keys	Security Features	Mitigated
PVE-005	High	Revisited Logic in cancelUnlock()	Business Logic	Fixed
PVE-006	Medium	Improved Quote Between depositToken and LP	Business Logic	Fixed
PVE-007	Low	Accommodation of Non-ERC20-Compliant Tokens	Coding Practices	Fixed

Besides recommending specific countermeasures to mitigate these issues, we also emphasize that it is always important to develop necessary risk-control mechanisms and make contingency plans, which may need to be exercised before the mainnet deployment. The risk-control mechanisms need to kick in at the very moment when the contracts are being deployed in mainnet. Please refer to Section 3 for details.

## 3 | Detailed Results

### 3.1 Revisited Logic To Calculate The Rewards

- ID: PVE-001
- Severity: Medium
- Likelihood: Medium
- Impact: Medium
- Target: WombatStaking
- Category: Business Logic [6]
- CWE subcategory: CWE-841 [3]

#### Description

The `WombatStaking` contract interacts with the `Wombat Exchange` to provide functionalities, such as adding new liquidity, staking LP token on `MasterWombat`, and staking `WOM` to get `veWom`. It provides an external `harvest()` interface for users or `WombatPoolHelper` to claim rewards from `MasterWombat`. Our analysis shows the current logic in reward calculation needs to be improved.

To elaborate, we show below the code snippet of the `harvest()` routine. By design, it is implemented to claim rewards from the specified pool in `MasterWombat` and send the rewards to the rewarder. Specially, if the caller is not the `Magpie` contracts, the caller can get the caller fee in `mWom`. The original fee in `WOM` is locked to get `veWom` via the `convertWOM()` routine (line 347). After that, the routine transfers `mWom` to the caller (line 348). However, the contract may not hold `mWom` at all, hence simply reverting the harvest operation. Our analysis shows that the `WOM` rewards will be converted to `mWom` by invoking `uint fee = IMWom(mWom).convert(feeAmount)` and the received `mWom` amount (`fee`) may be not equal to the `feeAmount` as the `veWom` may not be converted from `WOM` with the 1 : 1 conversion rate. As a result, it needs to transfer the `fee` amount of `mWom` to the caller: `IERC20(mWom).safeTransfer(msg.sender, fee).`

```

329  /// @notice harvest a Pool from MGP
330  /// @param _depositToken the address of the deposit token Pool to harvest
331  /// @param _isUser true if this function is not called by the magpie Contracts. The
    caller gets the caller fee
332  function harvest(
333      address _depositToken,
```

```

334     bool _isUser
335 ) _onlyActivePool(_depositToken) external {
336     Pool storage poolInfo = pools[_depositToken];
337     uint256 beforeBalance = IERC20(wom).balanceOf(address(this));
338     uint256[] memory pids = new uint256[](1);
339     pids[0] = poolInfo.pid;
340     IMasterWombat(masterWombat).multiClaim(pids); //only claim from a specific
        deposit token Pool
341
342     uint256 rewards = IERC20(wom).balanceOf(address(this)) - beforeBalance;
343     uint256 afterFee = rewards;
344     if (_isUser) {
345         uint256 feeAmount = (rewards * CALLER_FEE) / FEE_DENOMINATOR;
346         IERC20(wom).approve(mWom, feeAmount);
347         this.convertWOM(feeAmount);
348         IERC20(mWom).safeTransfer(msg.sender, feeAmount);
349         afterFee = afterFee - feeAmount;
350     }
351     sendRewards(poolInfo.depositToken, poolInfo.rewarder, rewards, afterFee);
352
353     emit WomHarvested(rewards, rewards - afterFee);
354 }
355
356 /// @notice convert WOM to mWOM
357 /// @param _amount the number of WOM to convert
358 /// @dev the WOM must already be in the contract
359 function convertWOM(uint256 _amount) external returns(uint256) {
360     uint256 veWomMintedAmount = 0;
361     if (_amount > 0) {
362         IERC20(wom).approve(veWom, _amount);
363         veWomMintedAmount = IVeWom(veWom).mint(_amount, IVeWom(veWom).maxLockDays())
            ;
364     }
365
366     emit WomConverted(_amount, IVeWom(veWom).maxLockDays());
367
368     return veWomMintedAmount;
369 }

```

Listing 3.1: WombatStaking::harvest()

**Recommendation** Revisit the above logic to properly convert the WOM to mWom and transfer the received amount of mWom to the caller.

**Status** The issue has been fixed by this commit: 4c0677d.

## 3.2 Incorrect Token Flow in withdraw()

- ID: PVE-002
- Severity: High
- Likelihood: Medium
- Impact: Medium
- Target: WombatPoolHelper/WombatStaking
- Category: Business Logic [6]
- CWE subcategory: CWE-841 [3]

### Description

The WombatPoolHelper is a helper smart contract to interact with WombatStaking (to provide liquidity on Wombat Exchange, etc.) and MasterMagpie (to stake LP token as a certificate and farm). While examining the token flow to withdraw assets from WombatPoolHelper, we notice the existence of incorrect token flow between WombatPoolHelper and WombatStaking which needs to be corrected.

To elaborate, we show below the code snippets of the WombatPoolHelper:withdraw() and WombatStaking:withdraw() routines. Specifically, the WombatPoolHelper:withdraw() takes the input \_amount of receiptToken and unstakes it from MasterMagpie (line 137). The unstaked receiptToken \_amount is then used in the WombatStaking:withdraw() function (line 140). However, within the WombatStaking:withdraw() function, the input \_amount is expected to be the amount of stables (\_depositToken) which will be provided to Wombat Exchange as liquidity. Our analysis shows that, the WombatPoolHelper:withdraw() could be refactored to take the input \_amount as the amount of the stables to withdraw which is the same as the WombatPoolHelper:deposit() (where the input \_amount represents the amount of the stables to deposit). With that, the WombatPoolHelper:withdraw() function shall convert the input \_amount of the stables to the amount of receiptToken which is needed to unstake from MasterMagpie.

```

136     function withdraw(uint256 _amount, uint256 _minAmount) external override _harvest {
137         _unstake(_amount, msg.sender);
138         IWombatStaking(wombatStaking).withdraw(
139             depositToken,
140             _amount,
141             _minAmount,
142             msg.sender
143         );
144         emit NewWithdraw(msg.sender, _amount);
145     }

```

Listing 3.2: WombatPoolHelper:withdraw()

```

294     function withdraw(
295         address _depositToken,
296         uint256 _amount,
297         uint256 _minAmount,
298         address _sender
299     ) _onlyPoolHelper(_depositToken) external {

```

```

300 // _amount is the amount of stable
301 Pool storage poolInfo = pools[_depositToken];
302 uint256 sharesAmount = getSharesForDepositTokens(_amount, _depositToken);
303 uint256 lpAmount = getLPTokensForShares(sharesAmount, _depositToken);
304 IMintableERC20(poolInfo.receiptToken).burn(msg.sender, sharesAmount);
305
306 IERC20(poolInfo.lpAddress).approve(poolInfo.depositTarget, lpAmount);
307 IMasterWombat(masterWombat).withdraw(poolInfo.pid, lpAmount);
308
309 uint256 beforeWithdraw = IERC20(_depositToken).balanceOf(address(this));
310 IWombatPool(poolInfo.depositTarget).withdraw(
311     _depositToken,
312     lpAmount,
313     _minAmount,
314     address(this),
315     block.timestamp
316 );
317
318 poolInfo.size -= _amount;
319 poolInfo.sizeLp -= lpAmount;
320
321 IERC20(_depositToken).safeTransfer(
322     _sender,
323     IERC20(_depositToken).balanceOf(address(this)) - beforeWithdraw
324 );
325
326 emit NewWithdraw(_sender, _depositToken, _amount);
327 }

```

Listing 3.3: WombatStaking.withdraw()

**Recommendation** Revised the WombatPoolHelper.withdraw() function to correct the token flow during assets withdrawal.

**Status** The issue has been fixed by this commit: 0b024dd.

### 3.3 Improved Sanity Checks For Function Parameters

- ID: PVE-003
- Severity: Low
- Likelihood: Low
- Impact: Medium
- Target: MasterMagpie
- Category: Coding Practices [5]
- CWE subcategory: CWE-1126 [1]

#### Description

The MasterMagpie contract is a MasterChef implementation in Magpie, which provides an incentive mechanism that rewards the staking of supported assets with MGP. The rewards are carried out by designating a number of staking pools into which supported assets can be staked. And stake holders are rewarded in proportional to their share of deposited token in the reward pool. The reward pools can be dynamically added via `add()` and the weights of supported pools can be adjusted via `set()`. When analyzing the pool update routine `set()`, we notice the need of properly validating the input pool before the new pool weight becomes effective.

To elaborate, we show below the code snippet of the `set()` routine. As the name indicates, it is used by the pool manager to update the weight, rewarder and locker for the pool given by the `_stakingToken`. At the beginning of the routine, it validates the input `_rewarder` and `_locker`. However, it does not validate the input pool. As a result, if the pool is an invalid one, this routine could successfully update the `totalAllocPoint` which will create an unfair reward distribution to stake holders.

```

615     function set(
616         address _stakingToken,
617         uint256 _allocPoint,
618         address _rewarder,
619         address _locker,
620         bool _overwrite
621     ) external _onlyPoolManager {
622         if (!Address.isContract(address(_rewarder)) && address(_rewarder) != address(0))
623             revert MustBeContractOrZero();
624
625         if (!Address.isContract(address(_locker)) && address(_locker) != address(0))
626             revert MustBeContractOrZero();
627
628         massUpdatePools();
629         totalAllocPoint =
630             totalAllocPoint -
631             tokenToPoolInfo[_stakingToken].allocPoint +
632             _allocPoint;
633
634         tokenToPoolInfo[_stakingToken].allocPoint = _allocPoint;
635     }

```

```

636     if (_overwrite) {
637         tokenToPoolInfo[_stakingToken].rewarder = _rewarder;
638         tokenToPoolInfo[_stakingToken].locker = _locker;
639     }
640
641     emit Set(
642         _stakingToken,
643         _allocPoint,
644         IBaseRewardPool(tokenToPoolInfo[_stakingToken].rewarder),
645         tokenToPoolInfo[_stakingToken].locker,
646         _overwrite
647     );
648 }

```

Listing 3.4: MasterMagpie::set()

Note it shares the same issue in the `updatePool()` routine which shall update only valid pools.

**Recommendation** Revisit the above mentioned routines to add proper sanity checks.

**Status** The issue has been fixed by this commit: `ce1715c`.

## 3.4 Trust Issue of Admin Keys

- ID: PVE-004
- Severity: Medium
- Likelihood: Medium
- Impact: Medium
- Target: Multiple contracts
- Category: Security Features [4]
- CWE subcategory: CWE-287 [2]

### Description

In the Magpie protocol, there is a privileged account, i.e., `owner`, that plays a critical role in governing and regulating the system-wide operations (e.g., set pool managers). Our analysis shows that this privileged account needs to be scrutinized. In the following, we use the `MasterMagpie` contract as an example and show the representative functions potentially affected by the privileges of the `owner` account.

Specifically, the privileged functions in `MasterMagpie` allow for the `owner` to set pool manager who can add/set the reward pools, toggle whether emergency withdraw is allowed, update the emission rate, etc.

```

95     function setPoolManagerStatus(address _account, bool _allowedManager)
96         external
97         onlyOwner
98     {
99         PoolManagers[_account] = _allowedManager;

```



```

100
101     emit PoolManagerStatus(_account, PoolManagers[_account]);
102 }
103
104 /// @notice update the status of emergencyWithdraw.
105 /// @notice WARNING : the contract should not be used after that action for anything
    other that withdrawing
106 function allowEmergency(bool _allow) external onlyOwner {
107     emergencyAllowed = _allow;
108
109     emit EmergencyUpdated(emergencyAllowed);
110 }
111
112 function updateEmissionRate(uint256 _mgpPerSec) public onlyOwner {
113     massUpdatePools();
114     uint256 oldEmissionRate = mgpPerSec;
115     mgpPerSec = _mgpPerSec;
116
117     emit UpdateEmissionRate(msg.sender, oldEmissionRate, mgpPerSec);
118 }

```

Listing 3.5: Example Privileged Operations in the MasterMagpie Contract

We understand the need of the privileged functions for contract maintenance, but at the same time the extra power to the owner may also be a counter-party risk to the protocol users. It is worrisome if the privileged owner account is a plain EOA account. Note that a multi-sig account could greatly alleviate this concern, though it is still far from perfect. Specifically, a better approach is to eliminate the administration key concern by transferring the role to a community-governed DAO.

**Recommendation** Promptly transfer the privileged account to the intended DAO-like governance contract. All changed to privileged operations may need to be mediated with necessary timelocks. Eventually, activate the normal on-chain community-based governance life-cycle and ensure the intended trustless nature and high-quality distributed governance.

**Status** This issue has been mitigated as the team confirms they plan to use multi-sig for all admin roles.

### 3.5 Revisited Logic in cancelUnlock()

- ID: PVE-005
- Severity: High
- Likelihood: Medium
- Impact: High
- Target: VLMGP
- Category: Business Logic [6]
- CWE subcategory: CWE-841 [3]

#### Description

The new Magpie protocol introduces a VLMGP contract as a locker for MGP. If a user locks MGP into this contract, the contract mints the same amount of vLMGP and deposits the vLMGP into MasterMagpie so that the user can get rewards. The user can unlock MGP any time, but MGP will be kept in the VLMGP contract for a cool-down period before they can be transferred to the user. In the cool-down period, the user has the chance to cancel the unlock, which re-deposits the MGP back into MasterMagpie.

To elaborate, we show below the code snippet of the `cancelUnlock()` routine. As the name indicates, it is used for users to cancel the unlock of the MGP in cool down. Specifically, it invokes the `_lock()` routine (line 280) to deposit the MGP back into MasterMagpie. However, it comes to our attention that the `_lock()` function will mint the same amount of vLMGP again for the users. As a result, users vLMGP balances are doubled. As a result, users can repeat `startUnlock()` and `unlock()` to gain as many vLMGP as they want and drain all the locked MGP from the contract.

```

270     function cancelUnlock(uint256 _slotIndex) external override whenNotPaused {
271         _checkIndexInBoundary(msg.sender, _slotIndex);
272         UserUnlocking storage slot = userUnlocks[msg.sender][_slotIndex];
273
274         if(slot.endTime <= block.timestamp)
275             revert NotInCoolDown();
276
277         if (slot.amountInCoolDown == 0)
278             revert UnlockedAlready();
279
280         _lock(msg.sender, msg.sender, slot.amountInCoolDown, false);
281
282         slot.amountInCoolDown = 0; // not in cool down anymore
283         emit ReLock(msg.sender, _slotIndex, slot.amountInCoolDown);
284     }

```

Listing 3.6: VLMGP::cancelUnlock()

**Recommendation** Revisit the logic of the `startUnlock()/unlock()` routines to avoid the double mint of vLMGP.

**Status** The issue has been fixed by this commit: 748be39.

### 3.6 Improved Quote Between depositToken and LP

- ID: PVE-006
- Severity: Medium
- Likelihood: Medium
- Impact: Medium
- Target: WombatStaking
- Category: Business Logic [6]
- CWE subcategory: CWE-841 [3]

#### Description

As mentioned in Section 3.1, the WombatStaking contract interacts with Wombat Exchange to facilitate users to deposit assets in Wombat and stake the LP in MasterWombat for yield. Moreover, the WombatStaking contract allows users to deposit Wombat LP into MasterWombat for yield. To incentivize users deposit in WombatStaking, it mints receiptToken to users who can further deposit the receiptToken into MasterMagpie for additional rewards.

To elaborate, we show below the code snippet of the depositLP() routine. As the name indicates, it is designed for users to deposit Wombat LP. Per current design, the amount of receiptToken to mint is the same as the amount of the depositToken. Therefore, in order to get the intended amount of receiptToken for the deposit of Wombat LP, it needs to calculate the amount of the depositToken (line 348). To achieve that, the contract implements the getDepositTokenAmtByLP() routine (as the code shown below) by referring to the logic in Wombat. However, it comes to our attention that the amount returned from the getDepositTokenAmtByLP() routine is in WAD, not in the decimals of the depositToken! To correct, there's a need to convert the decimals from WAD to the decimals of the depositToken.

Our analysis shows that Wombat provides an official interface, i.e., quotePotentialWithdraw(), which can be used to get the amount of the depositToken for the given amount of LP token.

```

334     function depositLP(
335         address _lpAddress,
336         uint256 _lpAmount,
337         address _for
338     ) nonReentrant whenNotPaused _onlyActivePoolHelper(_lpAddress) external {
339         // Get information of the Pool of the token
340         Pool storage poolInfo = pools[_lpAddress];
341
342         // Transfer lp to this contract and stake it to wombat
343         IERC20(poolInfo.lpAddress).safeTransferFrom(_for, address(this), _lpAmount);
344
345         _toMasterWomAndSendReward(_lpAddress, _lpAmount, true); // triggers harvest from
346                             wombat exchange
347
348         // update variables
349         uint256 calcdDepositTokenAmount = getDepositTokenAmtByLP(_lpAmount, poolInfo.
350                             lpAddress, poolInfo.depositTarget);

```

```

349     uint256 receiptTokenToMint = getSharesForDepositTokens(caledDepositTokenAmount,
        _lpAddress);
350     IMintableERC20(poolInfo.receiptToken).mint(msg.sender, receiptTokenToMint);
351     ...
352 }

```

Listing 3.7: WombatStaking:depositLP()

```

256 function getDepositTokenAmtByLP(uint256 _amount, address _lpToken, address
    _depositTarget)
257     public
258     view
259     returns (
260         uint256 amount
261     )
262 {
263     IAsset asset = IAsset(_lpToken);
264
265     require(asset.totalSupply() > 0 && asset.liability() > 0, "Insufficient liquidity");
266
267     uint256 ampFactor = IWombatPool(_depositTarget).ampFactor();
268     uint256 liabilityToBurn = (asset.liability() * _amount) / asset.totalSupply();
269
270     amount = withdrawalAmountInEquillImpl(
271         -int256(liabilityToBurn),
272         int256(uint256(asset.cash())),
273         int256(uint256(asset.liability())),
274         int256(ampFactor)
275     ).toUint256();
276 }

```

Listing 3.8: WombatStaking:getDepositTokenAmtByLP()

Similarly, as shown in the following code snippet, the `withdraw()` routine invokes a `getLPTokensForShares()` routine (line 372) to get the amount of LP token to withdraw from `MasterWombat`. Our analysis shows that `Wombat` also provides an interface, i.e., `quotePotentialDeposit()`, which can be used to get the amount of LP token for the given amount of the `depositToken`.

```

363 function withdraw(
364     address _lpToken,
365     uint256 _amount,
366     uint256 _minAmount,
367     address _sender
368 ) nonReentrant whenNotPaused _onlyPoolHelper(_lpToken) external {
369     // _amount is the amount of stable
370     Pool storage poolInfo = pools[_lpToken];
371     uint256 sharesAmount = getSharesForDepositTokens(_amount, _lpToken);
372     uint256 lpAmount = getLPTokensForShares(sharesAmount, _lpToken);
373
374     IERC20(poolInfo.lpAddress).approve(poolInfo.depositTarget, lpAmount);
375     _toMasterWomAndSendReward(_lpToken, lpAmount, false);
376 }

```

```

377     uint256 beforeWithdraw = IERC20(poolInfo.depositToken).balanceOf(address(this));
378     IWombatPool(poolInfo.depositTarget).withdraw(
379         poolInfo.depositToken,
380         lpAmount,
381         _minAmount,
382         address(this),
383         block.timestamp
384     );
385     ...
386 }

```

Listing 3.9: WombatStaking.withdraw()

**Recommendation** Properly use the correct Wombat interfaces to quote between the depositToken and the LP token.

**Status** The issue has been fixed by this commit: 748be39. And the team have refactored the contract to keep the amounts of the receiptToken and the deposited LP token as 1 : 1. Moreover, users need to provide the amount of LP token to the withdraw() routine. By doing so, there is no need to convert the amount between the depositToken and the LP token any more in this contract.

### 3.7 Accommodation of Non-ERC20-Compliant Tokens

- ID: PVE-007
- Severity: Low
- Likelihood: Low
- Impact: Medium
- Target: Multiple Contracts
- Category: Business Logic [6]
- CWE subcategory: CWE-841 [3]

#### Description

Though there is a standardized ERC-20 specification, many token contracts may not strictly follow the specification or have additional functionalities beyond the specification. In the following, we examine the transfer() routine and related idiosyncrasies from current widely-used token contracts.

In particular, we use the popular token, i.e., ZRX, as our example. We show the related code snippet below. On its entry of transfer(), there is a check, i.e., if (balances[msg.sender] >= \_value && balances[\_to] + \_value >= balances[\_to]). If the check fails, it returns false. However, the transaction still proceeds successfully without being reverted. This is not compliant with the ERC20 standard and may cause issues if not handled properly. Specifically, the ERC20 standard specifies the following: “Transfers \_value amount of tokens to address \_to, and MUST fire the Transfer event. The function SHOULD throw if the message caller’s account balance does not have enough tokens to spend.”

```

64     function transfer(address _to, uint _value) returns (bool) {
65         //Default assumes totalSupply can't be over max (2^256 - 1).
66         if (balances[msg.sender] >= _value && balances[_to] + _value >= balances[_to]) {
67             balances[msg.sender] -= _value;
68             balances[_to] += _value;
69             Transfer(msg.sender, _to, _value);
70             return true;
71         } else { return false; }
72     }

74     function transferFrom(address _from, address _to, uint _value) returns (bool) {
75         if (balances[_from] >= _value && allowed[_from][msg.sender] >= _value &&
76             balances[_to] + _value >= balances[_to]) {
77             balances[_to] += _value;
78             balances[_from] -= _value;
79             allowed[_from][msg.sender] -= _value;
80             Transfer(_from, _to, _value);
81             return true;
82         } else { return false; }
83     }

```

Listing 3.10: ZRX.sol

Because of that, a normal call to `transfer()` is suggested to use the safe version, i.e., `safeTransfer()`. In essence, it is a wrapper around ERC20 operations that may either throw on failure or return false without reverts. Moreover, the safe version also supports tokens that return no value (and instead revert or throw on failure). Note that non-reverting calls are assumed to be successful. Similarly, there is a safe version of `transferFrom()` as well, i.e., `safeTransferFrom()`.

In the following, we show the `compound()` routine in the `ManualCompound` contract. If the ZRX token is supported as `bonusTokenAddresses[j]`, the unsafe version of `IERC20(bonusTokenAddresses[j]).transfer(msg.sender, rewardBalance)` (line 144) may return `false` while not revert. Without a validation on the return value, the transaction can proceed even when the transfer fails. The same issue is present in `WombatStaking::_sendRewards()`.

```

129     function compound(address[] calldata _lps, bool _forLock) external {
130         uint256 rewardTokensLength = rewards.length;
131         uint256[] memory beforeBalances = new uint256[](rewardTokensLength);
132         for (uint256 i; i < rewardTokensLength; i++) {
133             beforeBalances[i] = IERC20(rewards[i].tokenAddress).balanceOf(msg.sender);
134         }
135
136         IMasterMagpie(masterMagpie).multicallOnBehalf(_lps, msg.sender);
137         address[] memory bonusTokenAddresses;
138         // send none compoundable reward back to caller
139         for (uint256 i; i < _lps.length; i++) {
140             (bonusTokenAddresses, ) = IMasterMagpie(masterMagpie).rewarderBonusTokenInfo(
141                 _lps[i]);
142             for (uint j; j < bonusTokenAddresses.length; j++) {
143                 if (!compoundableRewards[bonusTokenAddresses[j]]) {

```

```
143         uint256 rewardBalance = IERC20(bonusTokenAddresses[j]).balanceOf(  
144             address(this));  
145         IERC20(bonusTokenAddresses[j]).transfer(msg.sender, rewardBalance);  
146     }  
147 }  
148 ...  
149 }
```

Listing 3.11: ManualCompound::compound()

What's more, it is important to note that for certain non-compliant ERC20 tokens (e.g., USDT), the `approve()` function requires to reduce the allowance to 0 first if it is not, and then set the proper allowance. This requirement is in place to mitigate the known `approve()/transferFrom()` race condition (<https://github.com/ethereum/EIPs/issues/20#issuecomment-263524729>).

Because of that, a normal call to `approve()` with a currently non-zero allowance may fail. To accommodate the specific idiosyncrasy, there is a need to `approve()` twice: the first one reduces the allowance to 0, and the second one sets the new allowance. Moreover, a normal call to `approve()` is suggested to use the safe version, i.e., `safeApprove()`. In essence, it is a wrapper around ERC20 operations that may either throw on failure or return false without reverts. And the safe version also supports tokens that return no value (and instead revert or throw on failure). Note that non-reverting calls are assumed to be successful. Note the same issue is also present in other routines, e.g., `WombatStaking.deposit()/_sendRewards()` routines, etc.

**Recommendation** Accommodate the above-mentioned idiosyncrasies with safe-version implementation of ERC20-related `approve()/transfer()`. And there is a need to `approve()` twice: the first one reduces the allowance to 0, and the second one sets the new allowance.

**Status** The issue has been fixed by this commit: 748be39.

## 4 | Conclusion

In this audit, we have analyzed the `Magpie` design and implementation. `Magpie` is an innovative yield-boosting protocol that provides users with boosted stablecoin yields from the innovative stableswap platform – `Wombat Exchange`, without even having to hold the `WOM` token. Conversely, `WOM` holders can also benefit from `Magpie` by converting their `WOM` token into `mWOM` to earn a share of `Magpie`'s profit. The current code base is well structured and neatly organized. Those identified issues are promptly confirmed and addressed.

Meanwhile, we need to emphasize that `Solidity`-based smart contracts as a whole are still in an early, but exciting stage of development. To improve this report, we greatly appreciate any constructive feedbacks or suggestions, on our methodology, audit findings, or potential gaps in scope/coverage.





## References

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