# TSwap Protocol Audit Report

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## Protocol Summary

The TSwap protocol facilitates decentralized asset management through liquidity pools and token swaps, including functionalities for liquidity provision, fee calculation, and deadline management. The goal is to provide users with efficient and secure mechanisms to engage in asset exchanges.

## Disclaimer

Abdikadr Jerow from the Cyfrin.io team makes all efforts to identify vulnerabilities in the code within the given timeframe. However, no responsibility is assumed for the findings in this document. This audit serves as a security review of the Solidity implementation and does not endorse the underlying business or product.

## Risk Classification

| | | Impact | | |
|---|---|---|---|---|
| | | High | Medium | Low |
| Likelihood | High | H | H/M | M |
| | Medium | H/M | M | M/L |
| | Low | M | M/L | L |

We use the CodeHawks severity matrix to determine severity. See the documentation for more details.

# Executive Summary

## Issues found

| Severity | Number of Issues Found |
|---|---|
| High | 5 |
| Medium | 4 |
| Low | 2 |
| Informational | 9 |
| **Total** | **20** |

## Findings

### High Severity Issues

**[H-1] Uninitialized State Variables / Missing Deadline Check Description**:

- **Uninitialized State Variables**: Variables `s_pools` and `s_tokens` in `PoolFactory.sol` are declared but not initialized.
- **Missing Deadline Check**: The `deposit` function in `TSwapPool` does not utilize the `deadline` parameter.

**Impact**:

- Uninitialized variables can lead to unpredictable behavior or runtime errors, risking fund loss.
- Missing deadline checks may result in transactions occurring under unfavorable conditions.

**Proof of Concept**:

```
// PoolFactory.sol
mapping(address => Pool) public s_pools; // Uninitialized variable
mapping(address => Token) public s_tokens;

function createPool(address token) public {
    require(s_tokens[token].exists, "Token not registered");
}
```

```
// TSwapPool.sol
function deposit(uint256 wethToDeposit, uint256 deadline) external {
    // No deadline check implemented
    revertIfDeadlinePassed(deadline);
}
```

**Recommended Mitigation**:

- Initialize state variables in the constructor.
- Implement deadline checks in the `deposit` function.

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**[H-2] Reentrancy Vulnerability / Incorrect Fee Calculation Description**:

- **Reentrancy Vulnerability**: The `withdraw` function allows Ether transfers without reentrancy guards.
- **Incorrect Fee Calculation**: The `getInputAmountBasedOnOutput` function improperly calculates fees, resulting in excessive charges.

**Impact**:

- Reentrancy attacks could drain Ether from the contract.
- Incorrect fee calculations lead to unexpected user losses.

**Proof of Concept**:

```
function withdraw(uint amount) public {
    require(balances[msg.sender] >= amount, "Insufficient balance");
    msg.sender.call{value: amount}(""); // Reentrancy risk
}
```

```
function getInputAmountBasedOnOutput(uint256 outputAmount) public pure returns (uint256 inpu
    return ((inputReserves * outputAmount) * 1_000) / ((outputReserves - outputAmount) * 997
}
```

**Recommended Mitigation**:

- Use checks-effects-interactions pattern and add reentrancy guards.
- Correct the fee calculation scaling factor.

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**[H-3] Missing Access Control / Lack of Slippage Protection Description**:

- **Missing Access Control**: Critical functions lack access restrictions.
- **Lack of Slippage Protection**: The `swapExactOutput` function does not limit `maxInputAmount`.

**Impact**:

- Unauthorized access may allow fund drainage or state modifications.
- Users could face unexpected losses due to market volatility.

**Proof of Concept**:

```
function setAdmin(address newAdmin) public {
    admin = newAdmin; // No access control
}

function swapExactOutput(uint256 maxInputAmount) public {
    if (inputAmount > maxInputAmount) { revert(); }
    // ...
}
```

**Recommended Mitigation**:

- Implement access control with modifiers like `onlyOwner`.
- Add a `maxInputAmount` parameter to limit slippage.

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**[H-4] Overflow and Underflow Risks / SellPoolTokens Mismatches Description**:

- **Overflow and Underflow Risks**: Lacking SafeMath or built-in checks for arithmetic operations.
- **SellPoolTokens Mismatches**: Misuse of `swapExactOutput` in the `sellPoolTokens` function.

**Impact**:

- Risks of incorrect calculations may enable exploits.
- Users could receive incorrect token amounts.

**Proof of Concept**:

```
function addLiquidity(uint256 amount) public {
    totalSupply += amount; // Risk of overflow
}

function sellPoolTokens(uint256 poolTokenAmount, uint256 minWethToReceive) external {
    return swapExactInput(poolTokenAmount, minWethToReceive); // Mismatched function usage
}
```

**Recommended Mitigation**:

- Use SafeMath or upgrade to Solidity 0.8+.
- Correct `sellPoolTokens` to use the appropriate function.

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**[H-5] Improper Handling of Ether Transfers / Extra Tokens Issue**
**Description**:

- **Improper Handling of Ether Transfers**: No validation for successful Ether transfers.
- **Extra Tokens Issue**: `_swap` function grants extra tokens, violating the x * y = k invariant.

**Impact**:

- Inconsistent contract state may result from failed transfers.
- Broken invariants could allow fund drainage.

**Proof of Concept**:

```
function deposit() public payable {
    balances[msg.sender] += msg.value; // No validation for successful transfer
}

function _swap() internal {
    swap_count++;
    if (swap_count >= SWAP_COUNT_MAX) {
        swap_count = 0;
        outputToken.safeTransfer(msg.sender, 1_000_000_000_000_000_000); // Invariant violat
    }
}
```

**Recommended Mitigation**:

- Validate Ether transfers and include fallback functions.
- Adjust incentive mechanisms to maintain protocol invariants.

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**Medium Severity Issues**

**[M-1] Missing Indexed Fields in Events Description**:
Events lack indexed parameters, making it harder for external services to efficiently access event data.

**Impact**:
Increased off-chain processing costs and degraded user experience.

**Proof of Concept**:

```
event PoolCreated(address creator, address pool); // Missing indexed fields
```

**Recommended Mitigation**:
Add `indexed` parameters to events where appropriate.

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**[M-2] Use of Magic Numbers Description**:
Hardcoded "magic numbers" lack context, reducing clarity and making future updates error-prone.

**Impact**:
Potential confusion for maintainers and increased risk of mistakes.

**Proof of Concept**:

```
function setFee(uint fee) public {
    require(fee < 1000, "Fee too high"); // Magic number 1000 lacks context
}
```

**Recommended Mitigation**:
Define constants at the beginning of the contract for all magic numbers with descriptive names.

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**[M-3] Functions Not Marked External Description**:
Functions intended for external calls are not marked `external`, leading to higher gas usage.

**Impact**:
Increased gas costs for users.

**Proof of Concept**:

```
function calculateReward() public { ... } // Could be marked as external
```

**Recommended Mitigation**:
Mark functions for external use as `external` to optimize gas usage.

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**[M-4] Missing Function Comments  Description**:
Several functions lack comments explaining their purpose, parameters, or return values.

**Impact**:
Reduced clarity and increased risk of misuse during maintenance.

**Proof of Concept**:

```
function transfer(address to, uint256 amount) public { ... } // No comments
```

**Recommended Mitigation**:
Add comprehensive comments for all functions, detailing their purpose, parameters, and expected outcomes.

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**Low Severity Issues**

**[L-1] Redundant Code Blocks  Description**:
The contract contains unnecessary code blocks that could be simplified.

**Impact**:
Redundant code can lead to increased gas costs and potential maintenance challenges.

**Recommended Mitigation**:
Review and refactor redundant code blocks to improve efficiency.

**[L-2] Non-Optimized Storage Usage  Description**:
Some state variables are not optimized for

gas costs.

**Impact**:
Increased gas fees for users interacting with the contract.

**Recommended Mitigation**:
Evaluate and optimize state variable declarations for gas efficiency.

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**Informational Severity Issues**

**[I-1] Code Style Consistency  Description**:
Inconsistent naming conventions and formatting.

**Impact**:
Decreased code readability and increased difficulty in collaboration.

**Recommended Mitigation**:
Adopt a consistent coding style and formatting guidelines.

**[I-2] Lack of Unit Tests Description**:
Absence of unit tests to verify contract functionality.

**Impact**:
Increased risk of undetected issues during development.

**Recommended Mitigation**:
Implement comprehensive unit tests to ensure contract reliability.

**[I-3] Unused Variables Description**:
Several declared variables are not used in the code.

**Impact**:
Unnecessary complexity and increased gas costs.

**Recommended Mitigation**:
Remove unused variables to clean up the code.

**[I-4] Informational Events Description**:
Lack of events for critical actions like `setAdmin` or `updateFee`.

**Impact**:
Reduced transparency for users and external monitors.

**Recommended Mitigation**:
Emit events for significant actions to improve contract transparency.

**[I-5] Upgradeability Considerations Description**:
The protocol lacks mechanisms for upgradeability.

**Impact**:
Difficulties in implementing future improvements.

**Recommended Mitigation**:
Consider using a proxy pattern or similar mechanisms for upgradeability.

**[I-6] Documentation Quality Description**:
Limited documentation available for users and developers.

**Impact**:
Users may find it challenging to understand and use the protocol.

**Recommended Mitigation**:
Enhance documentation to provide clearer guidance on using the protocol.

**[I-7] External Dependency Verification Description**:
Lack of verification for external contracts or libraries.

**Impact**:
Increased risk from vulnerabilities in third-party dependencies.

**Recommended Mitigation**:
Implement checks to ensure external dependencies are secure and trusted.

**[I-8] Gas Limit Recommendations Description**:
No guidance on recommended gas limits for interactions.

**Impact**:
User experience may suffer due to unexpected gas limits.

**Recommended Mitigation**:
Provide recommendations for gas limits to improve user experience.

**[I-9] Code Comments and Documentation Description**:
The existing comments and documentation are insufficient.

**Impact**:
Difficulties in understanding the codebase for new developers.

**Recommended Mitigation**:
Enhance comments and documentation to provide better context and guidance.

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This structured format ensures clarity in the audit report, making it easier to navigate through findings, severity classifications, and recommended mitigations. If you have any additional details or modifications you'd like to make, let me know!