



# T-Swap Audit Report

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*r00tSid.github.io*

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r00tSid

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Prepared by: r00tSid

Lead Auditors: - r00tSid

## Table of Contents

- Table of Contents
- Protocol Summary
- Disclaimer
- Risk Classification
- Audit Details
  - Scope
  - Roles
- Executive Summary
  - Issues found
- Findings
  - High
    - \* [H-1] TSwapPool::deposit is missing deadline check causing transactions to complete even after the deadline
    - \* [H-2] Incorrect fee calculation in TSwapPool::getInputAmountBasedOnOutput causes protocol to take too many tokens from users, resulting in lost fees
    - \* [H-3] Lack of slippage protection in TSwapPool::swapExactOutput causes users to potentially receive way fewer tokens

- ★ [H-4] `TSwapPool::sellPoolTokens` mismatches input and output tokens causing users to receive the incorrect amount of tokens
- ★ [H-5] In `TSwapPool::_swap` the extra tokens given to users after every swap-Count breaks the protocol invariant of  $x * y = k$
- Low
  - ★ [L-1] `TSwapPool::LiquidityAdded` event has parameters out of order
  - ★ [L-2] Default value returned by `TSwapPool::swapExactInput` results in incorrect return value given
- Informationals
  - ★ [I-1] `PoolFactory::PoolFactory__PoolDoesNotExist` is not used and should be removed
  - ★ [I-2] Lacking zero address checks
  - ★ [I-3] `PoolFactory::createPool` should use `.symbol()` instead of `.name()`
  - ★ [I-4] Event is missing indexed fields

## Protocol Summary

This project is meant to be a permissionless way for users to swap assets between each other at a fair price. You can think of T-Swap as a decentralized asset/token exchange (DEX). T-Swap is known as an Automated Market Maker (AMM) because it doesn't use a normal "order book" style exchange, instead it uses "Pools" of an asset. It is similar to Uniswap. To understand Uniswap, please watch this video: [Uniswap Explained](#)

## Disclaimer

The individual r00tSid has made every effort to identify as many vulnerabilities as possible within the allotted time frame. However, no responsibility is assumed for the findings or any issues that may arise from the use of this document. This security audit does not constitute an endorsement of the underlying business, product, or project. The audit was strictly time-boxed and limited to reviewing the security aspects of the Solidity implementation of the smart contracts.

## 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.

## Audit Details

- Github Link: <https://github.com/Cyfrin/5-t-swap-audit>
- Commit Hash: e643a8d4c2c802490976b538dd009b351b1c8dda
- Solc Version: 0.8.20
- Chain(s) to deploy contract to: Ethereum

## Scope

./src/ #- PoolFactory.sol #- TSwapPool.sol

## Roles

- Liquidity Providers: Users who have liquidity deposited into the pools. Their shares are represented by the LP ERC20 tokens. They gain a 0.3% fee every time a swap is made.
- Users: Users who want to swap tokens.

## Executive Summary

The audit reviewed 2 Solidity files (~350 nSLOC) over 7+ hours, focusing on security and best practices. A total of 17 issues were identified: 4 High, 2 Medium, 2 Low, and 9 Informational. High and medium severity issues require urgent attention, while low and informational findings should be addressed to improve overall code quality and maintainability.

## Issues found

Severty	Number of issues found
High	4
Medium	2
Low	2
Info	9
Total	17

## Findings

### High

#### [H-1] TSwapPool::deposit is missing deadline check causing transactions to complete even after the deadline

**Description:** The `deposit` function accepts a deadline parameter, which according to the documentation is “The deadline for the transaction to be completed by”. However, this parameter is never used. As a consequence, operations that add liquidity to the pool might be executed at unexpected times, in market conditions where the deposit rate is unfavorable.

**Impact:** Transactions could be sent when market conditions are unfavorable to deposit, even when adding a deadline parameter.

**Proof of Concept:** The `deadline` parameter is unused.

**Recommended Mitigation:** Consider making the following change to the function.

```
function deposit(
    uint256 wethToDeposit,
    uint256 minimumLiquidityTokensToMint, // LP tokens -> if empty, we
    ↪ can pick 100% (100% == 17 tokens)
    uint256 maximumPoolTokensToDeposit,
    uint64 deadline
)
    external
+   revertIfDeadlinePassed(deadline)
    revertIfZero(wethToDeposit)
```

```
        returns (uint256 liquidityTokensToMint)
    {
```

## **[H-2] Incorrect fee calculation in TSwapPool::getInputAmountBasedOnOutput causes protocol to take too many tokens from users, resulting in lost fees**

**Description:** The `getInputAmountBasedOnOutput` function is intended to calculate the amount of tokens a user should deposit given an amount of tokens of output tokens. However, the function currently miscalculates the resulting amount. When calculating the fee, it scales the amount by 10\_000 instead of 1\_000.

**Impact:** Protocol takes more fees than expected from users.

### **Recommended Mitigation:**

```
function getInputAmountBasedOnOutput(
    uint256 outputAmount,
    uint256 inputReserves,
    uint256 outputReserves
)
public
pure
revertIfZero(outputAmount)
revertIfZero(outputReserves)
returns (uint256 inputAmount)
{
-     return ((inputReserves * outputAmount) * 10_000) / ((outputReserves
↪ - outputAmount) * 997);
+     return ((inputReserves * outputAmount) * 1_000) / ((outputReserves
↪ - outputAmount) * 997);
}
```

## **[H-3] Lack of slippage protection in TSwapPool::swapExactOutput causes users to potentially receive way fewer tokens**

**Description:** The `swapExactOutput` function does not include any sort of slippage protection. This function is similar to what is done in `TSwapPool::swapExactInput`, where the function specifies a `minOutputAmount`, the `swapExactOutput` function should specify a `maxInputAmount`.

**Impact:** If market conditions change before the transaction processes, the user could get a much worse swap.

**Proof of Concept:**

1. The price of 1 WETH right now is 1,000 USDC
2. User inputs a swapExactOutput looking for 1 WETH
  1. inputToken = USDC
  2. outputToken = WETH
  3. outputAmount = 1
  4. deadline = whatever
3. The function does not offer a maxInput amount
4. As the transaction is pending in the mempool, the market changes! And the price moves HUGE  
-> 1 WETH is now 10,000 USDC. 10x more than the user expected
5. The transaction completes, but the user sent the protocol 10,000 USDC instead of the expected 1,000 USDC

**Recommended Mitigation:** We should include a maxInputAmount so the user only has to spend up to a specific amount, and can predict how much they will spend on the protocol.

```
function swapExactOutput(
    IERC20 inputToken,
+    uint256 maxInputAmount,
    .
    .
    .
    inputAmount = getInputAmountBasedOnOutput(outputAmount,
↪ inputReserves, outputReserves);
+    if(inputAmount > maxInputAmount){
+        revert();
+    }
    _swap(inputToken, inputAmount, outputToken, outputAmount);
```

**[H-4] TSwapPool::sellPoolTokens mismatches input and output tokens causing users to receive the incorrect amount of tokens**

**Description:** The sellPoolTokens function is intended to allow users to easily sell pool tokens and receive WETH in exchange. Users indicate how many pool tokens they're willing to sell in the poolTokenAmount parameter. However, the function currently miscalculates the swapped amount.

This is due to the fact that the `swapExactOutput` function is called, whereas the `swapExactInput` function is the one that should be called. Because users specify the exact amount of input tokens, not output.

**Impact:** Users will swap the wrong amount of tokens, which is a severe disruption of protocol functionality.

**Proof of Concept:**

```
// Assume poolTokenAmount = 100
// User expects to sell exactly 100 pool tokens and receive WETH in return
TSwapPool.sellPoolTokens(100);

// Internally, this calls swapExactOutput instead of swapExactInput
// swapExactOutput interprets "100" as outputAmount (WETH to receive)
// This forces the function to pull an arbitrary calculated amount of pool
  ↪ tokens
// rather than exactly 100, leading to mismatched token flow.
```

**Code Snippet:**

```
function sellPoolTokens(
    uint256 poolTokenAmount
) external returns (uint256 wethAmount) {
    //@audit instead of swapExactOutput, should be swapExactInput
    return
        swapExactOutput(
            i_poolToken,
            i_wethToken,
            poolTokenAmount,
            uint64(block.timestamp)
        );
}
```

**Recommended Mitigation:**

Consider changing the implementation to use `swapExactInput` instead of `swapExactOutput`. Note that this would also require changing the `sellPoolTokens` function to accept a new parameter (ie `minWethToReceive` to be passed to `swapExactInput`)

```
function sellPoolTokens(
    uint256 poolTokenAmount,
+    uint256 minWethToReceive,
) external returns (uint256 wethAmount) {
-    return swapExactOutput(i_poolToken, i_wethToken, poolTokenAmount,
  ↪ uint64(block.timestamp));
```



```
+         return swapExactInput(i_poolToken, poolTokenAmount, i_wethToken,  
↪    minWethToReceive, uint64(block.timestamp));  
    }
```

Additionally, it might be wise to add a deadline to the function, as there is currently no deadline. (MEV later)

#### **[H-5] In TSwapPool::\_swap the extra tokens given to users after every swapCount breaks the protocol invariant of $x * y = k$**

##### **Description:**

The protocol follows a strict invariant of  $x * y = k$ . Where:

- x: The balance of the pool token
- y: The balance of WETH
- k: The constant product of the two balances

This means, that whenever the balances change in the protocol, the ratio between the two amounts should remain constant, hence the k. However, this is broken due to the extra incentive in the \_swap function. Meaning that over time the protocol funds will be drained.

The follow block of code is responsible for the issue.

```
    swap_count++;  
    if (swap_count >= SWAP_COUNT_MAX) {  
        swap_count = 0;  
        outputToken.safeTransfer(msg.sender, 1_000_000_000_000_000_000);  
    }
```

**Impact:** A user could maliciously drain the protocol of funds by doing a lot of swaps and collecting the extra incentive given out by the protocol.

Most simply put, the protocol's core invariant is broken.

##### **Proof of Concept:**

1. A user swaps 10 times, and collects the extra incentive of 1\_000\_000\_000\_000\_000\_000 tokens
2. That user continues to swap untill all the protocol funds are drained

Place the following into TSwapPool.t.sol.

```
function testInvariantBroken() public {
```

```

vm.startPrank(liquidityProvider);
weth.approve(address(pool), 100e18);
poolToken.approve(address(pool), 100e18);
pool.deposit(100e18, 100e18, 100e18, uint64(block.timestamp));
vm.stopPrank();

uint256 outputWeth = 1e17;

vm.startPrank(user);
poolToken.approve(address(pool), type(uint256).max);
poolToken.mint(user, 100e18);
pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
    pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
    pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
    pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
    pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
    pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
    pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
    pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
    pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
    pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));

int256 startingY = int256(weth.balanceOf(address(pool)));
int256 expectedDeltaY = int256(-1) * int256(outputWeth);

pool.swapExactOutput(poolToken, weth, outputWeth,
↪ uint64(block.timestamp));
vm.stopPrank();

uint256 endingY = weth.balanceOf(address(pool));
int256 actualDeltaY = int256(endingY) - int256(startingY);
assertEq(actualDeltaY, expectedDeltaY);
}

```

should account for the change in the  $x * y = k$  protocol invariant. Or, we should set aside tokens in the same way we do with fees.

```
-         swap_count++;  
-         // Fee-on-transfer  
-         if (swap_count >= SWAP_COUNT_MAX) {  
-             swap_count = 0;  
-             outputToken.safeTransfer(msg.sender, 1_000_000_000_000_000_000);  
-         }
```

## Low

### [L-1] TSwapPool::\_LiquidityAdded event has parameters out of order

**Description:** When the `LiquidityAdded` event is emitted in the `TSwapPool::_addLiquidityMintAndTransfer` function, it logs values in an incorrect order. The `poolTokensToDeposit` value should go in the third parameter position, whereas the `wethToDeposit` value should go second.

**Impact:** Event emission is incorrect, leading to off-chain functions potentially malfunctioning.

**Recommended Mitigation:**

```
- emit LiquidityAdded(msg.sender, poolTokensToDeposit, wethToDeposit);  
+ emit LiquidityAdded(msg.sender, wethToDeposit, poolTokensToDeposit);
```

### [L-2] Default value returned by TSwapPool::swapExactInput results in incorrect return value given

**Description:** The `swapExactInput` function is expected to return the actual amount of tokens bought by the caller. However, while it declares the named return value `output` it is never assigned a value, nor uses an explicit return statement.

**Impact:** The return value will always be 0, giving incorrect information to the caller.

**Recommended Mitigation:**

```
{  
    uint256 inputReserves = inputToken.balanceOf(address(this));  
    uint256 outputReserves = outputToken.balanceOf(address(this));  
  
-    uint256 outputAmount = getOutputAmountBasedOnInput(inputAmount,  
  ↪ inputReserves, outputReserves);  
+    output = getOutputAmountBasedOnInput(inputAmount, inputReserves,  
  ↪ outputReserves);  
}
```

```
-         if (output < minOutputAmount) {
-             revert TSwapPool__OutputTooLow(outputAmount, minOutputAmount);
+         if (output < minOutputAmount) {
+             revert TSwapPool__OutputTooLow(outputAmount, minOutputAmount);
        }

-         _swap(inputToken, inputAmount, outputToken, outputAmount);
+         _swap(inputToken, inputAmount, outputToken, output);
    }
```

## Informationals

### [I-1] PoolFactory::PoolFactory\_\_PoolDoesNotExist is not used and should be removed

```
- error PoolFactory__PoolDoesNotExist(address tokenAddress);
```

### [I-2] Lacking zero address checks

```
    constructor(address wethToken) {
+        if(wethToken == address(0)) {
+            revert();
+        }
        i_wethToken = wethToken;
    }
```

### [I-3] PoolFacotry::createPool should use .symbol() instead of .name()

```
-         string memory liquidityTokenSymbol = string.concat("ts",
- ↪     IERC20(tokenAddress).name());
+         string memory liquidityTokenSymbol = string.concat("ts",
+ ↪     IERC20(tokenAddress).symbol());
```

### [I-4] Event is missing indexed fields

Index event fields make the field more quickly accessible to off-chain tools that parse events. However, note that each index field costs extra gas during emission, so it's not necessarily best to index the maximum allowed per event (three fields). Each event should use three indexed fields if there are

three or more fields, and gas usage is not particularly of concern for the events in question. If there are fewer than three fields, all of the fields should be indexed.

- Found in src/TSwapPool.sol: Line: 44
- Found in src/PoolFactory.sol: Line: 37
- Found in src/TSwapPool.sol: Line: 46
- Found in src/TSwapPool.sol: Line: 43