CERTIK

Security Assessment

Illuvium Land Sale Protocol

May 18th, 2022

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Summary

This report has been prepared for Landsale to discover issues and vulnerabilities in the source code of the Illuvium Land Sale Protocol project as well as any contract dependencies that were not part of an officially recognized library. A comprehensive examination has been performed, utilizing Static Analysis and Manual Review techniques.

The auditing process pays special attention to the following considerations:

- Testing the smart contracts against both common and uncommon attack vectors.
- Assessing the codebase to ensure compliance with current best practices and industry standards.
- Ensuring contract logic meets the specifications and intentions of the client.
- Cross referencing contract structure and implementation against similar smart contracts produced by industry leaders.
- Thorough line-by-line manual review of the entire codebase by industry experts.

The security assessment resulted in findings that ranged from critical to informational. We recommend addressing these findings to ensure a high level of security standards and industry practices. We suggest recommendations that could better serve the project from the security perspective:

- Enhance general coding practices for better structures of source codes;
- Add enough unit tests to cover the possible use cases;
- Provide more comments per each function for readability, especially contracts that are verified in public;
- Provide more transparency on privileged activities once the protocol is live.

Overview

Project Summary

Project Name	Illuvium Land Sale Protocol
Platform	Ethereum
Language	Solidity
Codebase	https://github.com/IlluviumGame/land-sale-core
Commit	b331088ab710142b9776c053268303b7f189c1a4 a92d89d7e9dbdf4a3af6c3746cee1e0a0b9403c3

Audit Summary

Delivery Date	May 18, 2022 UTC
Audit Methodology	Static Analysis, Manual Review

Vulnerability Summary

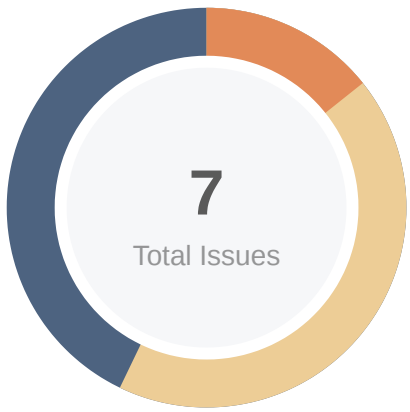
Vulnerability Level	Total	Pending	Declined	Acknowledged	Mitigated	Partially Resolved	Resolved
Critical	0	0	0	0	0	0	0
Major	1	0	0	1	0	0	0
Medium	0	0	0	0	0	0	0
Minor	3	0	0	0	0	0	3
Informational	3	0	0	0	0	0	3
Discussion	0	0	0	0	0	0	0

Audit Scope

ID	File	SHA256 Checksum
LSL	contracts/lib/LandSvgLib.sol	54cfd190738df3a10133a7168d62c6fa5e0a3da45d5e423f944afbcb71556915
ACI	contracts/utils/AccessControl.sol	79d1bef7dabe60a72b67d6c8865d3bd812c417f9d6629773386567b87b99e396
ERE	contracts/interfaces/ERC721SpecExt.sol	049587f274a3d53d35a115ee22d5d2c4a4d2e3050e456078421ce0d4f315fed9
LER	contracts/interfaces/LandERC721Spec.sol	781247e832e3e794b17580e3ce8640e455958eaaf1c3835a9528d5533995a6e5
ISG	contracts/interfaces/ImmutableSpec.sol	1aa1801d70c574322238c797a2e965e437d0922718e8cd9cfe46743941c9afa5
ERS	contracts/interfaces/ERC20Spec.sol	0697479909b8e127e2da1f60f3a8fea10ff975802c287a078b949beda3fba68b
LLI	contracts/lib/LandLib.sol	682eb85d05154e47e64ddf71c1b14ed0cc1eb4ee38d65abe2b41951384e1b1a1
LBL	contracts/lib/LandBlobLib.sol	66c7465e72d08e0e9e72f7e94cacf1efc4e69bc3149399133995b6906722ed76
ERG	contracts/token/ERC20Impl.sol	b71376843aba9209d8213723b152f3a92f049e386567249c57042537431433f1
UER	contracts/token/UpgradeableERC721.sol	a9c174dc25631a2843bf4bcefdefc10680946e8f95a79e2e4904fd5dbb84f9f9
LSI	contracts/protocol/LandSale.sol	0775898502278294f2c8617f1cad0082360707100de93146dd77c1d581bf30b7
LDI	contracts/token/LandDescriptorImpl.sol	13c3c53a2c4067875e8d8db56428f47b113b4307d802fc07ed46ed8cfebbb2c4
ECI	contracts/token/ERC721Impl.sol	2b1c59cb18460524741b3c4dc6004e89a989282027700 50e4a9b3e1b537583c8
LEC	contracts/token/LandERC721.sol	d2b137bac8cd4816c05ecf0c02dc1982336c32ae3764fd0176fcb7e7a03ca67d
ERC	contracts/interfaces/ERC165Spec.sol	c2b5c217e1130dc8dce304dde924ef52dde4c31a8a2be3e01f658ef4e2547fd6
RER	contracts/token/RoyalERC721.sol	dc3f068ed0a9576da9a5f5471313bce459312e1dae5a03b0a7c2732a5fdd837b

ID	File	SHA256 Checksum
ERI	contracts/interfaces/ERC721Spec.sol	ec4dff135822086a9b4584194425f80359d0082bd9c1ac31b5ec6ef01ca9a2b4
EIP	contracts/interfaces/EIP2981Spec.sol	20f08c667cf60e02956eef5c108fa76bccc058d53f7c50d5e23a5698cae99443
POS	contracts/interfaces/PriceOracleSpec.sol	d551550eb2120d070f4b39785b1fd5c6a06d8765d9886bfb0a42ae17394d06e3
ISI	contracts/interfaces/IdentifiableSpec.sol	057e7616143e59190337cd4f856292a7dfe0e9531d3f6e5cebd12b3c84d37dda
UAC	contracts/utils/UpgradeableAccessControl.sol	28b6e16cfb07169b54ade92977b9a50799a23506f9513c6505362030db2f0085
LSP	contracts/protocol/LandSalePriceOracleV1.sol	5b404b1ec9c743c56ec7ac936d43c0dfc031188687227c915276e2faac865cf7

Findings



Critical	**0** (0.00%)
Major	**1** (14.29%)
Medium	**0** (0.00%)
Minor	**3** (42.86%)
Informational	**3** (42.86%)
Discussion	**0** (0.00%)

ID	Title	Category	Severity	Status
IGB-01	Lack Of Input Validation	Volatile Code	Minor	Resolved
IGB-02	Requisite Value Of ERC-20 `transferFrom()` / `transfer()` Call	Logical Issue	Minor	Resolved
IGB-03	Missing Error Messages	Coding Style	Informational	Resolved
IGT-01	Missing Emit Events	Coding Style	Informational	Resolved
LSI-01	Centralization Related Risks	**Centralization / Privilege**	**Major**	Acknowledged
LSI-02	`_pauseDuration` Incorrectly Emitted	Logical Issue	Informational	Resolved
LSP-01	Hardcoded Oracle Answer Update Timeframe	Coding Style	Minor	Resolved

IGB-01 | Lack Of Input Validation

Category	Severity	Location	Status
Volatile Code	Minor	contracts/token/LandERC721.sol: 38, 46, 285; contracts/lib/LandLib.sol: 200	Resolved

Description

in `setMetadata()`, there are no input validations on `Site Type` and `Landmark Type ID`, where

- `Site Type` must be in the range of [1, 6]
- `Landmark Type ID` must be in the range of [0, 7]

Recommendation

Consider adding the require() checks for `Site Type` and `Landmark Type ID` in `setMetadata()`

Alleviation

`[CertiK]`: The team heeded the advice and resolved the finding in the commit a92d89d7e9dbdf4a3af6c3746cee1e0a0b9403c3

IGB-02 | Requisite Value Of ERC-20 `transferFrom()` / `transfer()` Call

Category	Severity	Location	Status
Logical Issue	Minor	contracts/interfaces/ERC20Spec.sol: 107, 132; contracts/protocol/LandSale.sol: 1; contracts/token/ERC721Impl.sol: 1; contracts/token/UpgradeableERC721.sol: 1	Resolved

Description

While the ERC-20 implementation does necessitate that the `transferFrom()` / `transfer()` function returns a `bool` variable yielding `true`, many token implementations do not return anything i.e. Tether (USDT) leading to unexpected halts in code execution.

Recommendation

We advise that the `SafeERC20.sol` library is utilized by OpenZeppelin to ensure that the `transferFrom()` / `transfer()` function is safely invoked in all circumstances.

Alleviation

`[CertiK]`: The team heeded the advice and resolved the finding in the commit a92d89d7e9dbdf4a3af6c3746cee1e0a0b9403c3

IGB-03 | Missing Error Messages

Category	Severity	Location	Status
Coding Style	Informational	contracts/protocol/LandSale.sol: 480, 481; contracts/mocks/ChainlinkAggregatorV3Mock.sol: 102	Resolved

Description

The **require** can be used to check for conditions and throw an exception if the condition is not met. It is better to provide a string message containing details about the error that will be passed back to the caller.

Recommendation

We advise adding error messages to the linked **require** statements.

Alleviation

`[CertiK]`: The team heeded the advice and resolved the finding in the commit [a92d89d7e9dbdf4a3af6c3746cee1e0a0b9403c3]

IGT-01 | Missing Emit Events

Category	Severity	Location	Status
Coding Style	Informational	contracts/token/UpgradeableERC721.sol: 321, 348; contracts/token/ERC20Impl.sol: 117, 158; contracts/token/ERC721Impl.sol: 306, 333	Resolved

Description

There should always be events emitted in the sensitive functions that are controlled by centralization roles.

Recommendation

It is recommended emitting events for the sensitive functions that are controlled by centralization roles.

Alleviation

`[CertiK]`: The team heeded the advice and resolved the finding in the commit a92d89d7e9dbdf4a3af6c3746cee1e0a0b9403c3

LSI-01 | Centralization Related Risks

Category	Severity	Location	Status
Centralization / Privilege	**Major**	contracts/protocol/LandSale.sol: 1	Acknowledged

Description

In the contract `LandSale.sol`, the following roles has authority over the following functions:

- `ROLE_DATA_MANAGER` role has authority over function `setInputDataRoot()`
- `ROLE_SALE_MANAGER` role has authority over function `initialize()`
- `ROLE_PAUSE_MANAGER` role has authority over function `pause()`
- `ROLE_PAUSE_MANAGER` role has authority over function `resume()`
- `ROLE_WITHDRAWAL_MANAGER` role has authority over function `setBeneficiary()`
- `ROLE_WITHDRAWAL_MANAGER` role has authority over function `withdrawTo()`
- `ROLE_RESCUE_MANAGER` role has authority over function `rescueErc20()`
-

Any compromise to the privileged roles may allow a hacker to take advantage of this authority and update the sensitive settings and execute sensitive functions of the project.

Recommendation

The risk describes the current project design and potentially makes iterations to improve in the security operation and level of decentralization, which in most cases cannot be resolved entirely at the present stage. We advise the client to carefully manage the privileged account's private key to avoid any potential risks of being hacked. In general, we strongly recommend centralized privileges or roles in the protocol be improved via a decentralized mechanism or smart-contract-based accounts with enhanced security practices, e.g., multi-signature wallets.

Indicatively, here are some feasible suggestions that would also mitigate the potential risk at a different level in terms of short-term, long-term and permanent:

Short Term:

Timelock and Multi sign (⅔, ⅗) combination *mitigate* by delaying the sensitive operation and avoiding a single point of key management failure.

- Time-lock with reasonable latency, e.g., 48 hours, for awareness on privileged operations;
  AND
- Assignment of privileged roles to multi-signature wallets to prevent a single point of failure due to the private key compromised;
  AND
- A medium/blog link for sharing the timelock contract and multi-signers addresses information with the public audience.

Long Term:

Timelock and DAO, the combination, *mitigate* by applying decentralization and transparency.

- Time-lock with reasonable latency, e.g., 48 hours, for awareness on privileged operations;
  AND
- Introduction of a DAO/governance/voting module to increase transparency and user involvement;
  AND
- A medium/blog link for sharing the timelock contract, multi-signers addresses, and DAO information with the public audience.

Permanent:

Renouncing the ownership or removing the function can be considered *fully resolved*.

- Renounce the ownership and never claim back the privileged roles;
  OR
- Remove the risky functionality.

Noted: Recommend considering the long-term solution or the permanent solution. The project team shall make a decision based on the current state of their project, timeline, and project resources.

Alleviation

`[Illuvium]`: Current deployment process implies transferring all the roles to Illuvium eDAO mSig wallet (4/6 signatures) It also implies that any permissions which are no longer required to extend, or/and upgrade the protocol to be revoked from the mSig We have a long-term plan to move these permissions to the DAO smart contract with time-lock feature, controlled by the community in the decentralized way. This design is well-known to the public and is the same for all the Illuvium smart contracts, including Illuvium Token itself,

Staking contracts, and others; these contracts are operating in the mainnet for more then a year, admin transactions from our mSig are transparent

Multi-sign proxy address:
https://etherscan.io/address/0xBc83a1dCc9352F4C9Aa7e9CF5A47e01D369dF87a

LSI-02 | `_pauseDuration` Incorrectly Emitted

Category	Severity	Location	Status
Logical Issue	Informational	contracts/protocol/LandSale.sol: 629	Resolved

Description

In the function `initialize()`, when the sale is in paused state, the value of `_pauseDuration` will be incorrectly emitted in the `Resumed` event.

Recommendation

Consider emitting `pauseDuration + now32() - pausedAt` in the event.

Alleviation

`[CertiK]`: The team heeded the advice and resolved the finding in the commit [a92d89d7e9dbdf4a3af6c3746cee1e0a0b9403c3]

LSP-01 | Hardcoded Oracle Answer Update Timeframe

Category	Severity	Location	Status
Coding Style	Minor	contracts/protocol/LandSalePriceOracleV1.sol: 81	Resolved

Description

The oracle update timeframe is hardcoded as 30 days, which lacks of readability and maintenance

Recommendation

Consider creating a variable and setter for the oracle answer update timeframe.

Alleviation

`[CertiK]`: The team heeded the advice and resolved the finding in the commit [a92d89d7e9dbdf4a3af6c3746cee1e0a0b9403c3]

Appendix

Finding Categories

Centralization / Privilege

Centralization / Privilege findings refer to either feature logic or implementation of components that act against the nature of decentralization, such as explicit ownership or specialized access roles in combination with a mechanism to relocate funds.

Logical Issue

Logical Issue findings detail a fault in the logic of the linked code, such as an incorrect notion on how block.timestamp works.

Volatile Code

Volatile Code findings refer to segments of code that behave unexpectedly on certain edge cases that may result in a vulnerability.

Coding Style

Coding Style findings usually do not affect the generated byte-code but rather comment on how to make the codebase more legible and, as a result, easily maintainable.

Checksum Calculation Method

The "Checksum" field in the "Audit Scope" section is calculated as the SHA-256 (Secure Hash Algorithm 2 with digest size of 256 bits) digest of the content of each file hosted in the listed source repository under the specified commit.

The result is hexadecimal encoded and is the same as the output of the Linux "sha256sum" command against the target file.

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