

# Beanstalk Protocol

## Barn (Post-Exploit Recapitalization)

In May 2021, Beanstalk was exploited via a governance attack. The exploiter used a flash loan to acquire a 2/3 supermajority of Stalk and then transferred all of the Deposited assets in the Silo to a different address. They then removed all of the liquidity into their underlying assets, rendering the Bean token liquidityless.

Upon exploit, Beanstalk was Paused and all functionality was removed from the protocol.

DAO Members voted on Snapshot based on the Stalk distribution prior to the attack, on how Beanstalk should proceed.

The solution was the Barn Raise where the community came together to Replant a new Beanstalk. During the Barn Raise, Beanstalk issued Unripe Bean and Unripe LP tokens in place of Bean and LP Silo Deposits that existed prior to the attack. All Silo Deposits (Bean:Eth, Bean:3CRV + Bean:LUSD) all receive Unripe LP tokens.

The Barn allows Farmers to purchase Fertilizer for 1 USDC. For each 1 USDC contributed, Beanstalk mints 0.824296 ( 824\_296 ) Beans, adds it to the whitelisted Bean:3Crv liquidity pool, and distributes it equally to all Unripe LP token holders. The Barn mints an additional amount of Beans proportional to the % of Deposited Beans that have been paid back to Unripe Bean holders and distribute the Beans to Unripe Bean holders. The Barn will continue to offer Fertilizer until the exploit has been fully recapitalized.

### Unripe Assets

Upon Replanting, Beanstalk will mint Unripe Beans and Unripe LP to all holders of Bean and Bean LP tokens in the block prior to the attack. As the Barn Raise sells Fertilizer, it will distribute Beans to all Unripe Bean holders pro rata using the shares and underlying token model that [EIP-4626](#) uses for Yield bearing tokens. The Unripe tokens are the Shares and Beans/LP are the underlying assets. The underlying portion will continue to fill up as Fertilizer is minted in exchange for USDC and Beanstalk is recapitalized.

Farmers can Ripen their Unripe assets at any point for a penalized percent of their corresponding underlying tokens. The penalized percent is equal to the percent of Unfertilized Beans that have been Fertilized. This can be computed as  $s.fertilizedIndex / s.unfertilizedIndex$ .

Unripe assets can still be Converted between Unripe Beans and Unripe LP.

### Unripe Beans

Beanstalk issues 1 Unripe Bean for every existing Bean in the block prior to the exploit. This includes:

- Deposited Beans – Bean Deposited into the Silo;
- Withdrawn Beans – Bean in the process of being Withdrawn;
- Farmable Beans – Bean seignorage in the Silo that has not yet been Deposited in a particular Season;
- Harvestable Beans – Beans that are Harvestable Pods;
- Circulating Beans – Beans that are in Farming, Maturity, and

- Circulating Beans – Beans that are in Farmers' wallets; and
- Ordered Beans – Beans that are stored in Pod Orders.

Beanstalk will mint 1 Unripe Bean directly to the Silo for each Deposited Bean in the block prior to the exploit. Beanstalk will also issue 1 Unripe Bean in the form of a Claimable Unripe Bean for all other existing Beans.

## Unripe LP

Beanstalk issues 1 Unripe LP for every existing BDV of LP at the time of the exploit in the BEAN:ETH Uniswap V2 Pool, the BEAN:3CRV metapool and the BEAN:LUSD pool.

This includes:

- Deposited LP – LP Deposited into the Silo
- Withdrawn LP – LP in the process of being Withdrawn
- Circulating LP – LP that is in a Farmer's wallets.

Beanstalk will mint 1 Unripe LP directly to the Silo for each BDV of Deposited LP in the block prior to the exploit. Beanstalk will also issue 1 Unripe LP for each BDV of Withdrawn or Circulating LP in the form of a Claimable Unripe LP token. It uses the BDV in the block prior to the exploit for each of the 3 different types of LP tokens.

## Fertilizer

Fertilizer is an ERC-1155 issued for participation in the Barn Raise. Fertilizer entitles holders to a pro rata portion of 1/3 of Bean mints if the Fertilizer is Active. Fertilizer can be minted as long as the recapitalization target has not been reached. When Fertilizer is minted, it is minted at a given % Humidity and is immediately Active. Each Fertilizer entitles its holder up to  $1 + \text{humidity}$  Unfertilized Beans. Unfertilized Beans become Fertilized Bean when Beans are distributed to Fertilizer holders. When Fertilizer has no more corresponding Unfertilized Beans, it becomes Inactive and no longer receives Bean mints.

To track Active Fertilizer, Beanstalk has a global variable `s.bpf`, which is the cumulative fertilizer paid back at every season. Fertilizer is indexed by  $\text{endBpf} = \text{s.bpf} + 1 + \text{humidity}$  at the time of minting. This signals that once `s.bpf` reaches `endBpf`, the Fertilizer becomes inactive. Beanstalk sorts all non-zero Fertilizer Ids by `endBpf` in `s.endBpfs`. It stores this in a linked list where `s.fFirst` is the start of the list and `s.fLast` is the end of the list.

Every Season Beanstalk increments `s.bpf` by the number of new Bean mints distributed to fertilizer divided by `s.activeFertilizer`. Note that Beanstalk integrates `s.bpf` over `s.activeFertilizer`, every time `s.bpf` reaches `s.fFirst`, `s.activeFertilizer` decreases by the supply of Fertilizer with an id of `s.fFirst`. It then pops the first item off of the linked list and sets `s.fFirst` to the next item. When `s.fFirst == 0`, Beanstalk stops paying Beans to Fertilizer as all Fertilizer is inactive and `s.activeFertilizer = 0`.

Humidity is dependent on the Season. During Season 6074 (The Season Beanstalk was paused at), the Humidity is 500%. The next Season, Humidity will be set to 250% and will continue to decrease by 0.5% every Season until it reaches 20%, at which point it will remain at 20% until all Fertilizer is sold.

Before Beanstalk is Unpaused, Fertilizer is deployed as `FertilizerPreMint.sol`, which transfers USDC from the caller to the Beanstalk Community Multisig address in exchange for Fertilizer. The Fertilizer is issued at the id `6_000_000` as the Humidity is 500%

When Beanstalk is unpaused, the BCM will call the function

```
addFertilizerOwner( uint128 id, uint128 amount, uint256 minLP ) external
```

which will handle the process of adding BEAN:3CRV liquidity and minting new Deposited Bean for all of the Fertilizer minted prior to Unpause.

At the same time, the Fertilizer contract will be upgraded to `Fertilizer.sol`. This will move the `mintFertilizer` functionality to Beanstalk itself instead of happening in the Fertilizer contract. At this point, Beanstalk will automatically add new liquidity for Unripe LP holders and new Beans in the same transaction as when Fertilizer is minted. Beanstalk will also start to automatically change the Fertilizer Id as describe above.

Fertilizer can be claimed via the `claimFertilizer` function or it is claimed automatically whenever Fertilizer is transferred. The Fertilizer contract stores the `lastBpf` value for each token Id that the Farmer owns. When a Farmer claims Fertilizer, Beanstalk computes how many Beans have been Fertilized since the last time the Farmer Fertilized that Id with:  $\min(s.bpf, s.endBpfs[id]) - lastBpf$ . It then gives the Farmer that many Beans for each Fertilizer they have of that id.