Curve Lending

soft-liquidation for the win!

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About me

@martinkrung

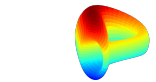
How soft-liquidation works in curve lending

I explain how soft-liquidation works in curve lending with real life positions, the technical implementation of soft-liquidation and what's needed to open a permissionless lending market on curve. I cover benefits and risk for users and projects.

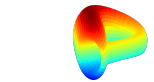
Day: 8-7-2024
Track: Decentralised Finance

Curve Today

Curve is an AMM
Curve iscrvUSD
Curve is lending market

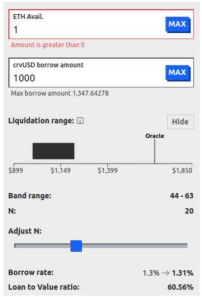


crvUSD pioneered soft-liquidation



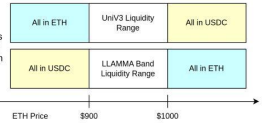
Loans

- To create a loan you have control over three variables:
  - collateral - The amount of ETH/wBTC/etc to deposit and borrow against
  - debt - The amount of crvUSD you want to borrow
  - N - The number of bands to split the collateral into
- Increasing amount collateral lets you borrow more crvUSD (increase debt)
- Increasing N either decreases the amount you can borrow (if the midpoint for the liquidation range needs to move lower as it widens to stay under current price band) or puts you into soft liquidation earlier (if midpoint can stay the same as range widens). See liquidation ranges and band sections for more details
- To max borrow set N=4.
- The max loan to value (LTV) = 88.88% which is the highest of any platform in DeFi
- Collateral is deposited in LLAMMA where bands are defined



LLAMMA

- Inverse AMM where in a ETH/USDC pair you can be all in ETH when price is high and all in USDC when price is low
- There is one LLAMMA contract for each collateral type, eg. ETH/crvUSD
- Each loan has it's collateral set to be sold in many small price ranges (like UniV3 positions) called bands
- MEV searchers are incentivised to trade through LLAMMA to rebalance it to the oracle price



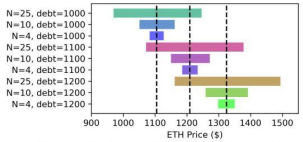
Difference between a UniV3 Liq range and a LLAMMA band's liq range

Liquidation Ranges

- Liquidation Ranges are defined by 4 variables:
  - N - number of bands, controlled by the user
  - debt - crvUSD you borrow, controlled by the user
  - oraclePrice - current market price of collateral, eg. ETH/crvUSD, controlled by market forces
  - A - amplification factor of collateral in LLAMMA, controlled by the CurveDAO
- Your Liquidation Range is spread evenly around a midpoint as shown by the vertical black dashed lines in the below chart. The midpoint can be estimated to be:

$$\text{midpoint} = \text{debt} \times 1.1$$

- The midpoint does not rely on N, only the amount of debt you borrow
- Increasing N increases the amount of higher and lower bands from the midpoint
- *Note the chart below looks like it spreads through more higher priced bands than lower priced bands. This is because bands increase in size at higher prices as well as the midpoint only being an estimation*



Liquidity ranges after borrowing different amounts of crvUSD debt and changing N

Loan Health / Hard Liquidation

- Loan health is a measure of how much your collateral is worth and how much debt you have. It is calculated based on the following formula:

$$\text{health} = \text{collatVal}\left[\frac{1 - \text{liqDiscount}}{\text{debt}}\right] - 1$$

where:
- collatVal - the collateral valuation based on current LLAMMA prices not current Oracle prices (see soft liquidation section for explanation)
- liqDiscount - the liquidation discount which is 6% for all markets currently
- debt - the amount of crvUSD borrowed

- When your health is 0% your collateral will be worth 106% of your debt
- Hard liquidations only occur when your health is under 0%
- It is possible to be below the liquidity range and have all your collateral converted to crvUSD while still having positive health. At this point you are unable to get hard liquidated by any further downwards price movements. You will lose health from interest accuring to your debt and for trading fees occured moving back up through the bands if price increases

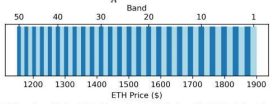
Bands

- Collateral is allocated to and split evenly between the number of bands (N) chosen by the user
- The minimum number of bands is N=4, the max is N=50
- Bands are defined for all loans based on two variables:
  - A - the amplification coefficient (can be defined for each LLAMMA collateral type but currently all are set to 100)
  - basePrice - the oracle price at contract deployment increased over time by the flucuating interest rate of each LLAMMA collateral type
- Each band can have many loans. So bands are not defined specifically for each loan, each loan will go into a range of the current LLAMMA bands
- The price range of any band n is exactly defined by:

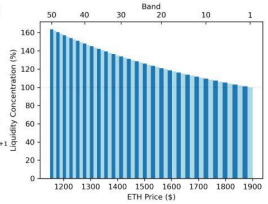
$$\text{bandUpperLimit} = \text{basePrice}\left[\frac{A-1}{A}\right]^{n} \qquad \text{bandLowerLimit} = \text{basePrice}\left[\frac{A-1}{A}\right]^{n+1}$$

- The width of the any band at any oracle price can be estimated to be:

$$\text{bandWidth} \approx \frac{\text{oraclePrice}}{A}$$



50 bands with A = 100. Note that the 50th band is 60% of the size of the 1st band



50 bands each with the same area showing the increased concentration of liquidity at the higher bands

- All current LLAMMA markets on Curve all have A=100. This means the 50th band is 40% smaller than the 1st band and liquidity is concentrated 60% more at the 50th band compared to the first band. You can see these relationships in the images to the left and above
- Bands drift higher over time as the base_price increases in proportion to the current interest rate

Soft Liquidations

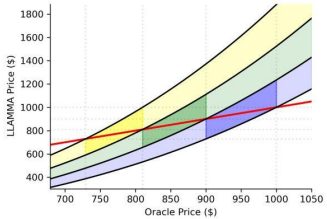
How they work:
When LLAMMA price enters a band you have collateral in, you enter soft liquidation.

The top right image shows how LLAMMA should rebalance its collateral through its bands in an ideal world:

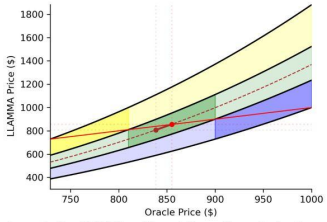
- There is an Oracle price (external price) and a LLAMMA price (internal price in LLAMMA). The red line illustrates the scenario where the oracle price equals the LLAMMA price, typically occurring during smooth price fluctuations.
- The different colours are different bands:
  - Blue is a band with a range of $900-$1000
  - Green is a band with a range of $810-$900
  - Yellow is a band with a range of ~$730-$810
- Bands are defined by Oracle price. Darker shading means you are in the normal price range, lighter shading means you are outside the normal range of the band
- If the oracle price is higher than the band range, the band should be all in the collateral, eg. ETH. If the oracle price is lower than band range the band should be all in crvUSD
- eg. if oracle price is at $855 we are in the middle of the green band, so the blue band should be 100% in crvUSD, the green band should have 50% ETH, 50% crvUSD, while the yellow band should be 100% in ETH
- Collateral is evenly sold through the band. The blue band range is from $900 to $1000. If the price is $980 we have decended $20 through the band and have $80 left to go. We have decended 20% through the band and so 20% of the collateral should be converted to crvUSD at this point

LLAMMA uses price differences between oracle price and it's own price to incentivise anyone to route trades through LLAMMA and rebalance the bands. It can set the LLAMMA price at a discount if it needs a rebalance quickly. An example of this is the image on the bottom right. It works in the following way:

- Let's start at the red dot half way through the green band where oracle price = LLAMMA price = $855.
- If suddenly we get a drop and oracle price updates to $840 and no one rebalances in the same block we move along the dashed brown line and end up at the brown dot.
- LLAMMA knows it has to rebalance here so it tries to sell collateral off cheap. The band range is $810 to $900, the price decreases from $855 to $840, it needs to sell:
  ($855 - $840) / ($900 - $810) = ~17%
  So LLAMMA sells 17% of the collateral in the green band at $800 to rebalance quickly and then sets LLAMMA price back to equal oracle price (on the red line). Anyone with collateral in the band loses the following amount to rebalancing fees:
  17% x ($840-800) / $840 = ~0.8% of their collateral in the band
- If big price moves occur bands can move out of their normal range and sell collateral off at very low prices, eg. If price went from $855 (red dot) to $750 LLAMMA would sell collateral at $575
- Big price swings have been used to illustrate how this works, but because price oracles update frequently and arbitrage is so competitive, large price swings without instant rebalances are very rare and LLAMMA and oracle prices roughly do follow the red line.



The oracle price (real price of ETH) vs. the current LLAMMA price of ETH. Red line is when oracle_price = LLAMMA_price. LLAMMA price should follow the red line if no big sudden price movements occur. Note in this example A=10 so we had nice numbers for bands, but A=100 in all crvUSD markets today.



A example of how LLAMMA incentivises rebalances when oracle price changes occur. Note in this example A=10 so we had nice numbers for bands, but A=100 in all crvUSD markets today.

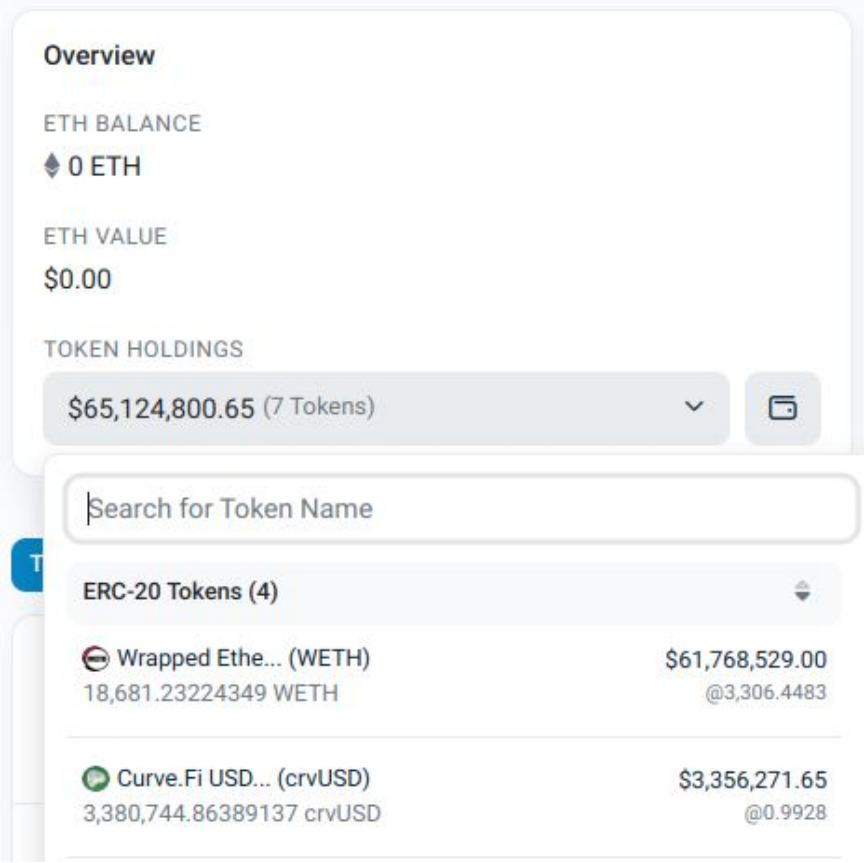
What it all means:

- Higher amplication factor (A) means higher impermanent loss if price moves against you but it is also erased quickly if price moves back up
- Having a low number of bands (low N) is seen as less risky which is why it allows a higher LTV ratio. Because there are less bands there should be less rebalancing losses if price action is smoothly up or down. Use low N if you predict crab markets/low volatility.
- High number of band loans (high N) protect better against external liquidation with sharp price drops, as there is more time to react and a wider spread of collateral. Use high N if you predict high volatility.

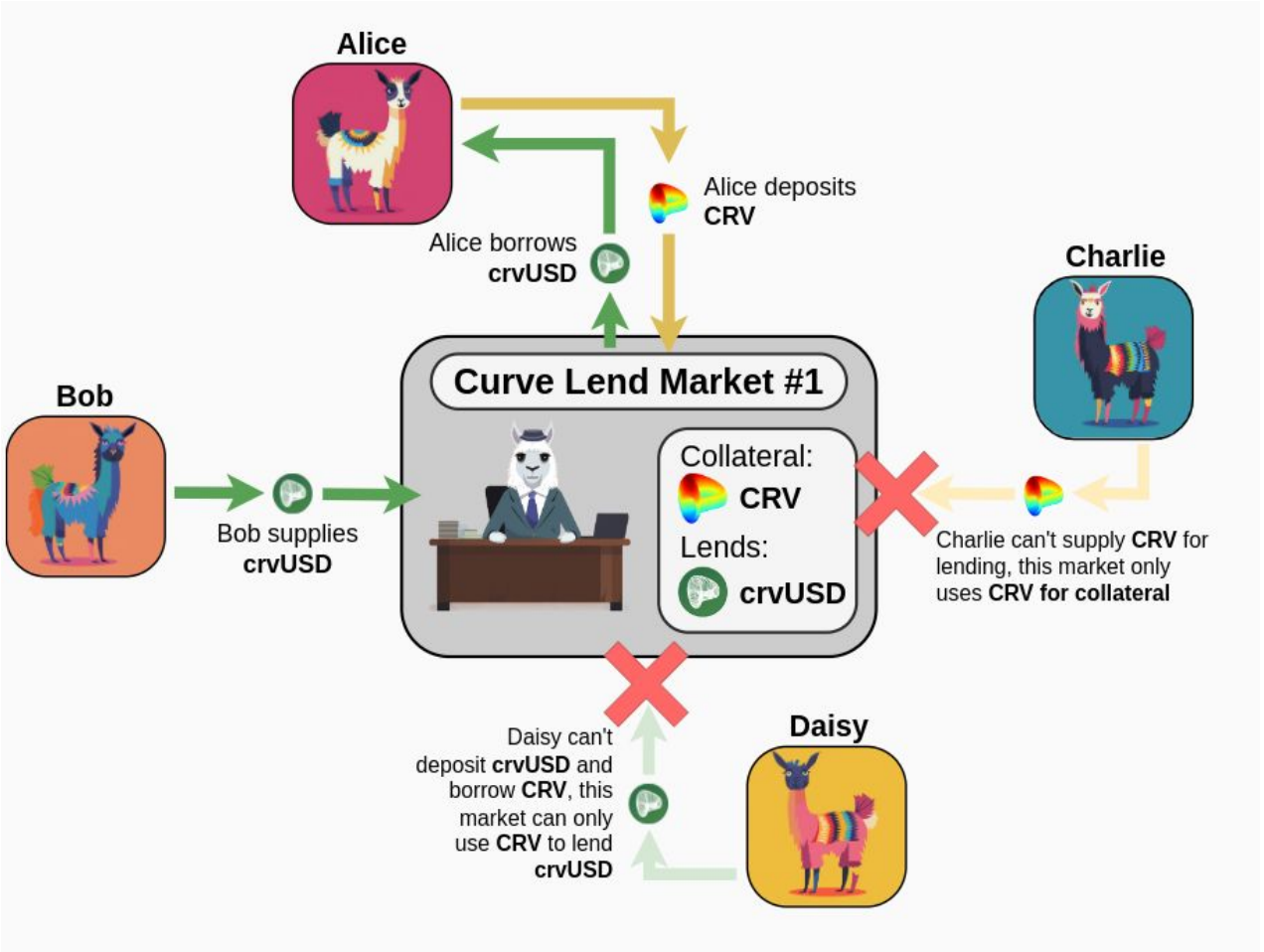
crvUSD minting

Markets	Borrow rate	↓ Total debt	Cap	Available to borrow	Total collateral value
ETH	25.15% → 25.19%	42.78M	200M	157.22M	$64.89M
WBTC	27.37% → 25.02%	35.65M	200M	164.35M	$68.39M
wstETH	36.03% → 35.66%	28.29M	150M	121.71M	$44.24M
sfrxETH v2	38.84% → 35.83%	10.83M	50M	39.17M	$16.33M
tBTC	27.20% → 24.64%	3.61M	50M	46.39M	$5.65M
sfrxETH	23.86% → 34.76%	276,621	0	0	$807,654

Mint crvUSD with ETH as collateral



ETH to mint crvUSD: https://etherscan.io/address/0x1681195c176239ac5e72d9aebacf5b2492e0c4ee

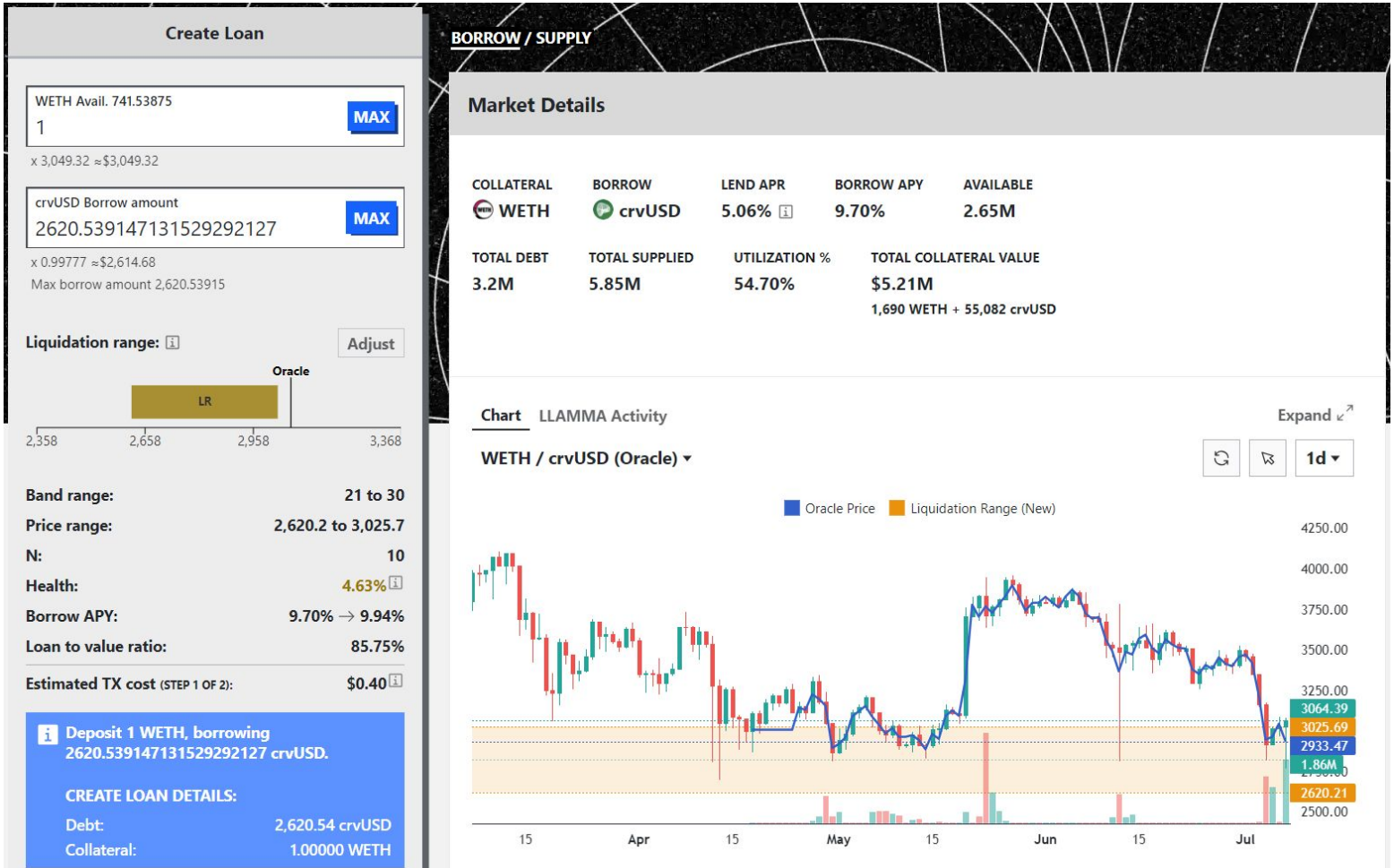


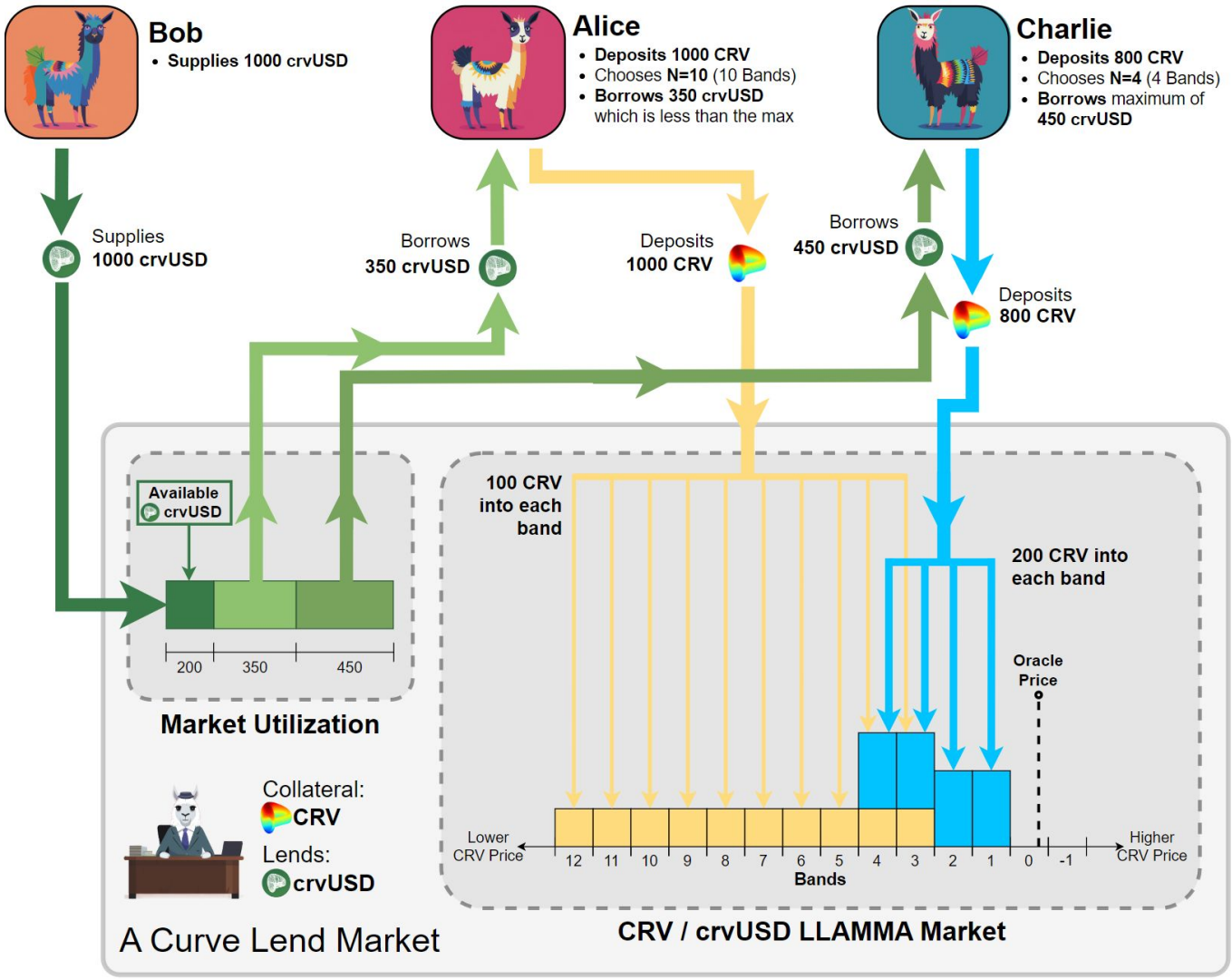
Curve Lending is a single side market

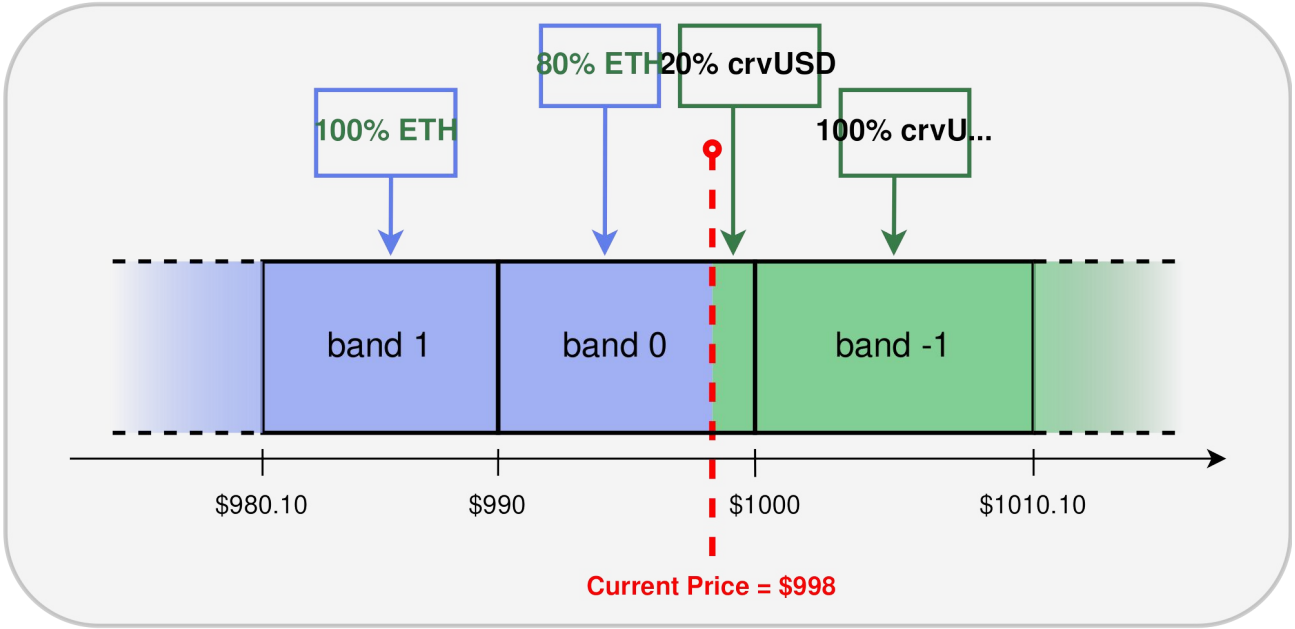
What Soft-liquidation needs

- Needs a on-chain price feed
- Needs liquidity to be arbitraged
- Needs collateral filled in bands

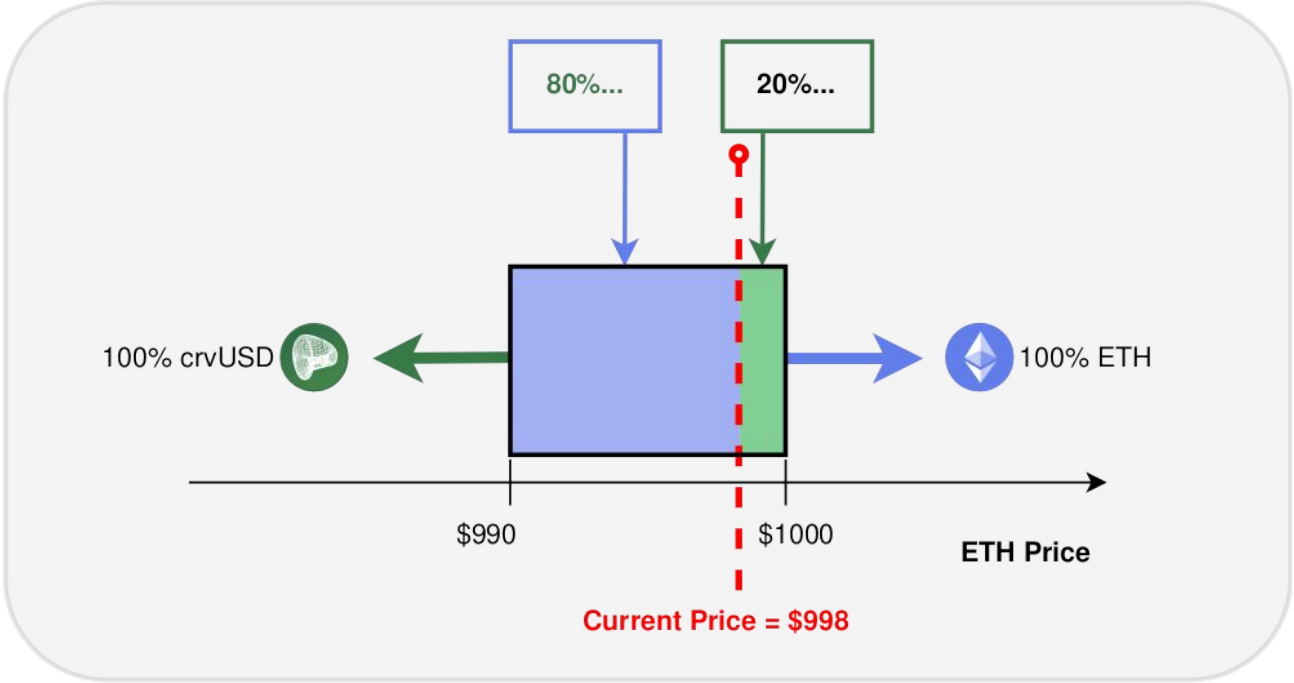
Curve lending




Bob
• Supplies 1000 crvUSD
Alice
• Deposits 1000 CRV
• Chooses N=10 (10 Bands)
• Borrows 350 crvUSD
which is less than the max
Charlie
• Deposits 800 CRV
• Chooses N=4 (4 Bands)
• Borrows maximum of
450 crvUSD
Supplies
1000 crvUSD
Borrows
350 crvUSD
Deposits
1000 CRV
Borrows
450 crvUSD
Deposits
800 CRV
Available
crvUSD
200
350
450
Market Utilization
100 CRV
into each
band
200 CRV into
each band
Oracle
Price
Lower
CRV Price
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
Higher
CRV Price
Bands
Collateral:
CRV
Lends:
crvUSD
A Curve Lend Market
CRV / crvUSD LLAMMA Market



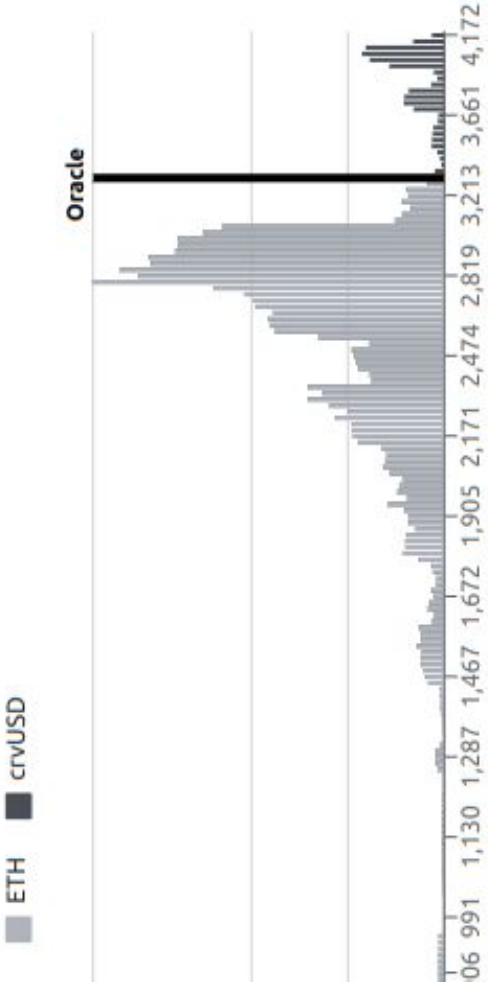
LLAMMA Bands in Soft-Liquidation



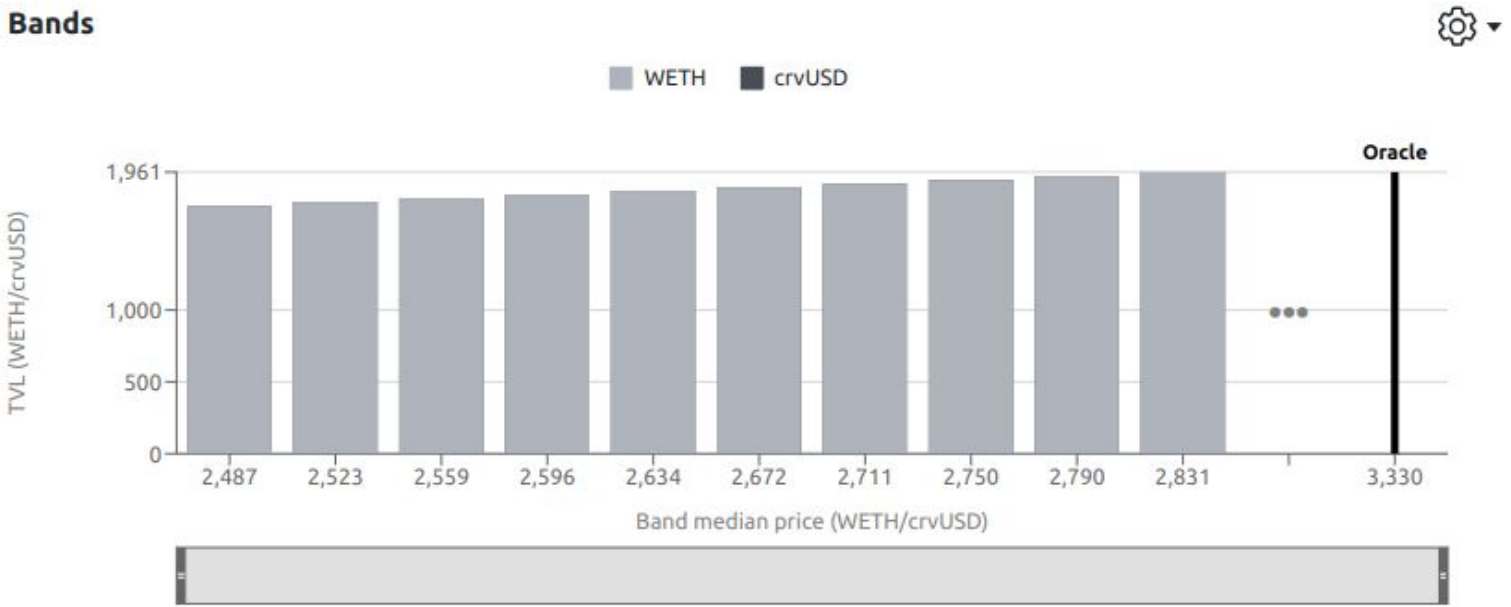
LLAMMA Band in Soft-Liquidation

crvUSD with ETH collateral

Bands can be seen as stop loss orders!

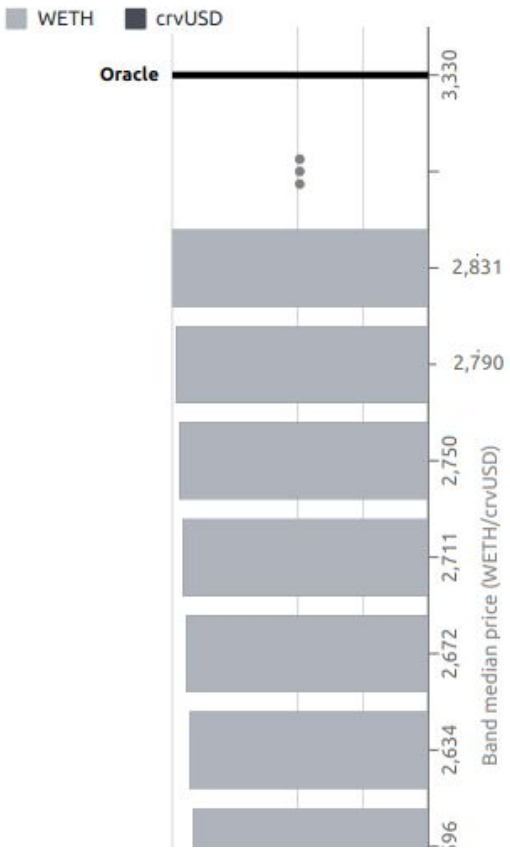


10 Bands for one position



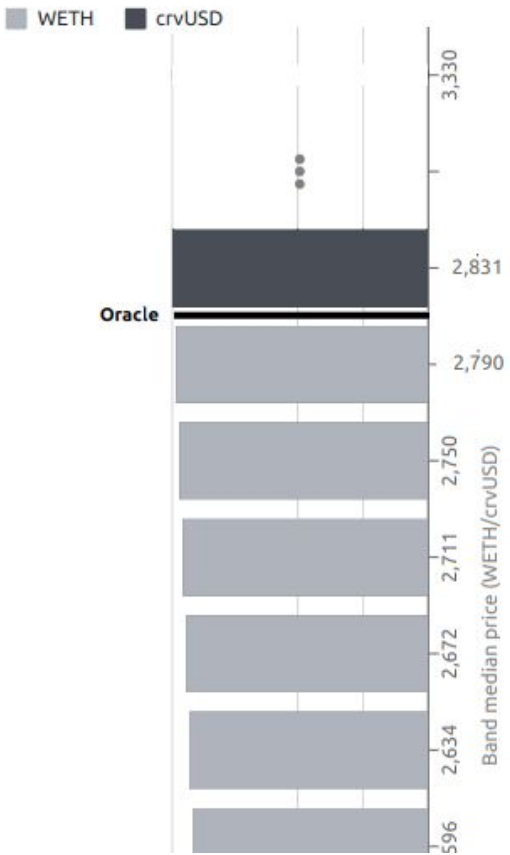
Oracle/Price above bands

Collateral position full in ETH



Oracle/Price moves down

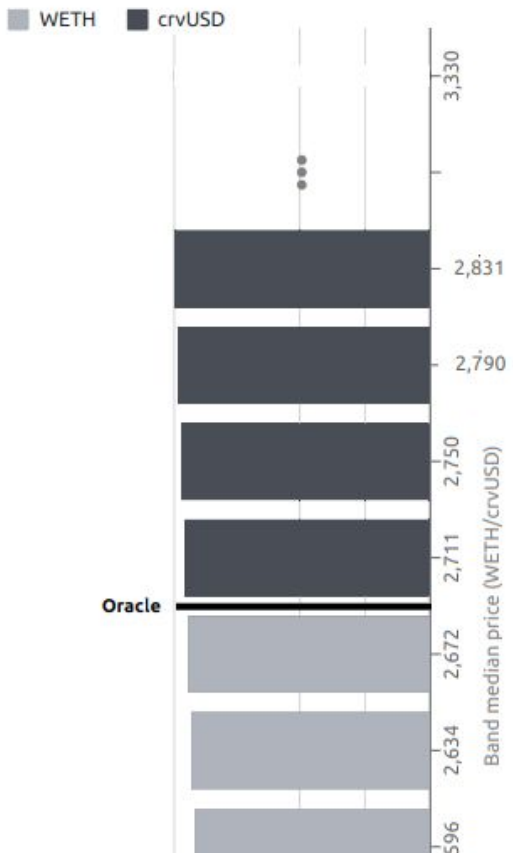
Collateral position in crvUSD and in ETH



Oracle/Price moves down

More ETH sold!

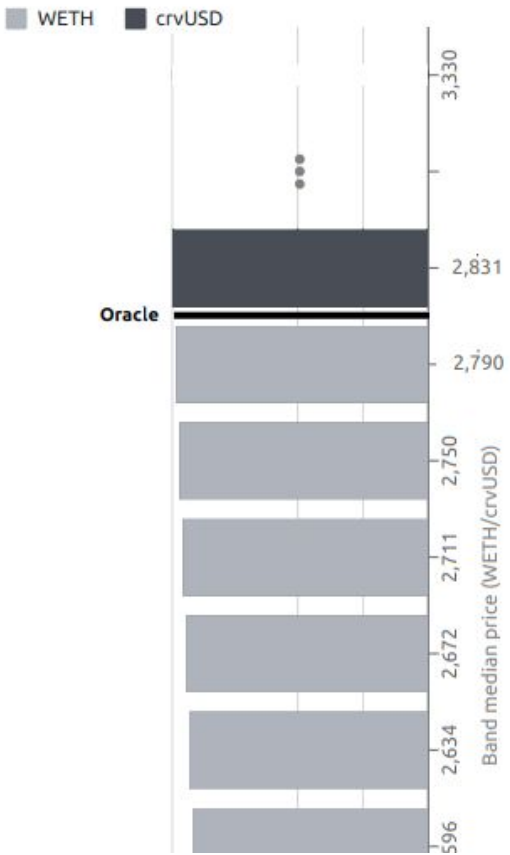
This is soft liquidation



Oracle/Price moves up

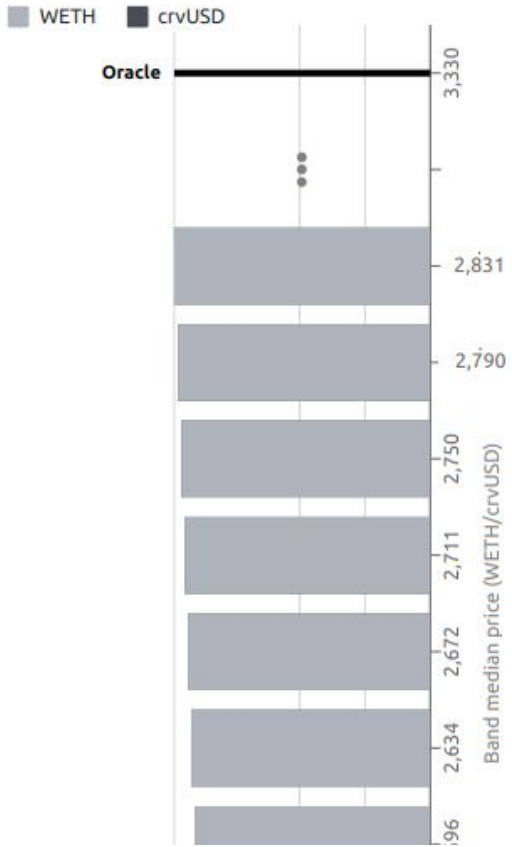
ETH bought back with crvUSD!

De-liquidation



Full recovery!

Collateral position full in ETH



User 0x23bf
3.July

You are in soft-liquidation mode. The amount currently at risk is 14.81994 ETH and 51,515.93834 crvUSD. In this mode, you cannot partially withdraw or add more collateral to your position. To reduce the risk of hard liquidation, you can repay or, to exit soft liquidation, you can close (self-liquidate).

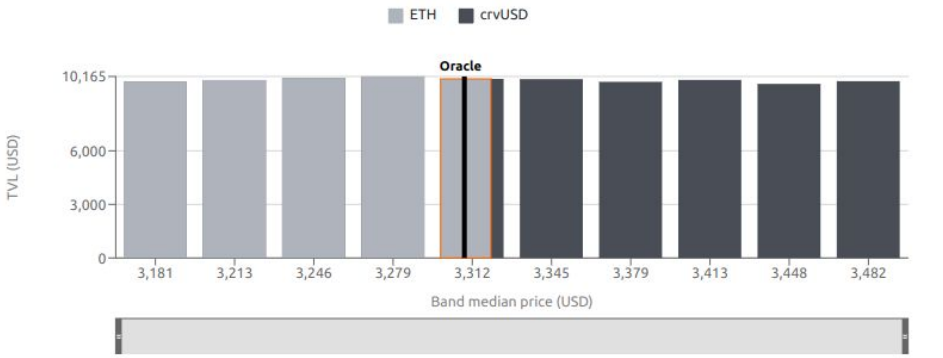
STATUS	HEALTH
Soft liquidation	4.79%

LIQUIDATION RANGE	BAND RANGE	RANGE %	BORROW RATE
3,165.28 to 3,499.93	-52 to -43	9.56%	29.80% → 30.29%

Collateral

CURRENT BALANCE (EST.) / DEPOSITED	LOSS AMOUNT	% LOST
29.92359 / 31.10341	1.17982	3.79%

Bands



LLAMMA Balances		Wallet Balances	
crvUSD	51,515.93834	crvUSD	0
ETH	14.81994	ETH	0.41649
Total debt:	89,292.38306		

User 0x23bf
7.July

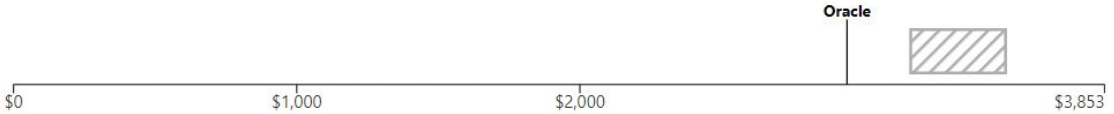
You are in soft-liquidation mode. The amount currently at risk is 99,008.01244 crvUSD. In this mode, you cannot partially withdraw or add more collateral to your position. To reduce the risk of hard liquidation, you can repay or, to exit soft liquidation, you can close (self-liquidate).

STATUS	HEALTH	LIQUIDATION RANGE	BORROW RATE
Soft liquidation	4.13%	3,168.16 - 3,503.12	15.51% → 16.48%

Collateral

CURRENT BALANCE (EST.) / DEPOSITED	LOSS AMOUNT	% LOST
29.73158 / 31.10341	1.37183	4.41%

Liquidation Range



LLAMMA Balances		Wallet Balances	
crvUSD	99,008.01244	crvUSD	0
ETH	0	ETH	0.41649
Total debt:	89,373.64380		

User 0x23bf
7. July

0x23bf
7 July

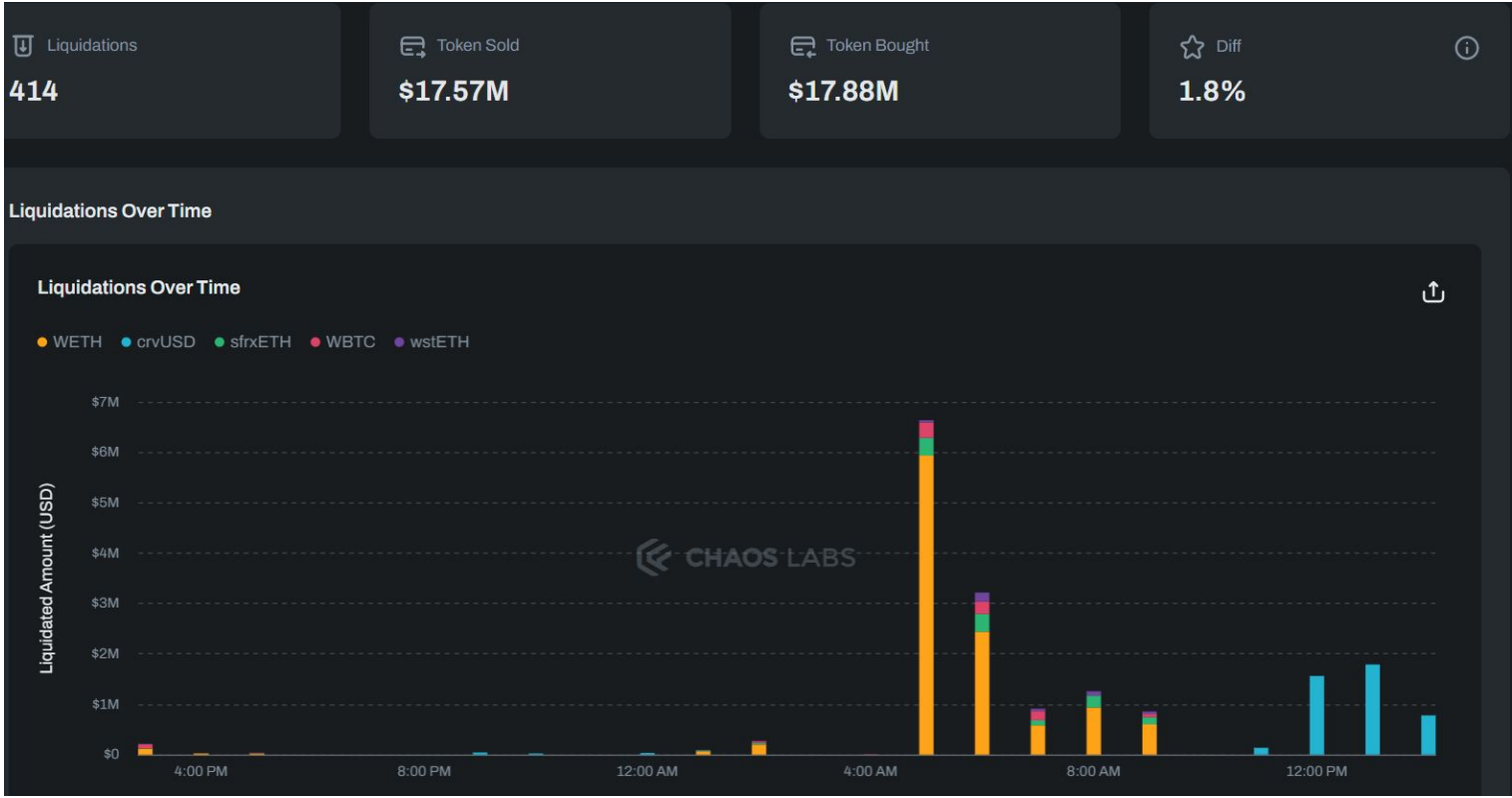
0x23bf


Liquidation Range
Oracle Price
$3.15K
CHAOS LABS
$0
$1K
$2K
$3K
$4K
$4.2K

0x23bf

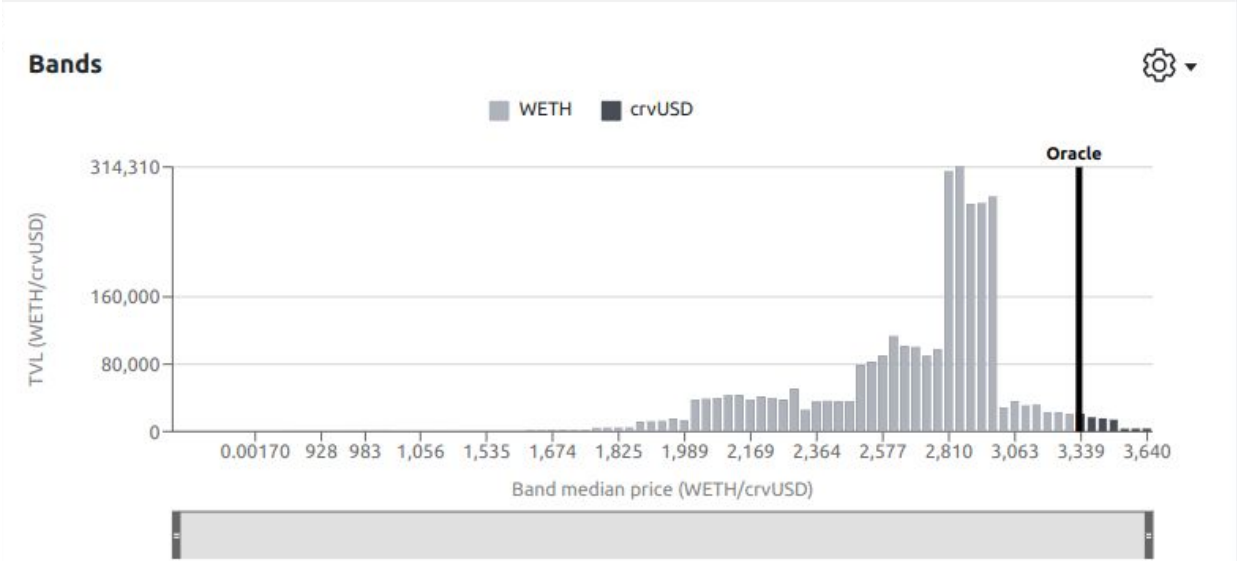

Liquidation Range
Oracle Price
$2.92K
CHAOS LABS
$0
$1K
$2K
$3K
$4K
$4.2K

5 July


Liquidations
414
Token Sold
$17.57M
Token Bought
$17.88M
Diff
1.8%
Liquidations Over Time
Liquidations Over Time
WETH
crvUSD
sfrxETH
WBTC
wstETH
$7M
$6M
$5M
$4M
$3M
$2M
$1M
$0
Liquidated Amount (USD)
CHAOS LABS
4:00 PM
8:00 PM
12:00 AM
4:00 AM
8:00 AM
12:00 PM

COLLATERAL	BORROW	LEND APR	BORROW APY	AVAILABLE
WETH	crvUSD	14.34%	17.90%	432,392

TOTAL DEBT	TOTAL SUPPLIED	UTILIZATION %	TOTAL COLLATERAL VALUE
2.9M	3.34M	87.04%	$3.90M 1,157 WETH + 74,422 crvUSD

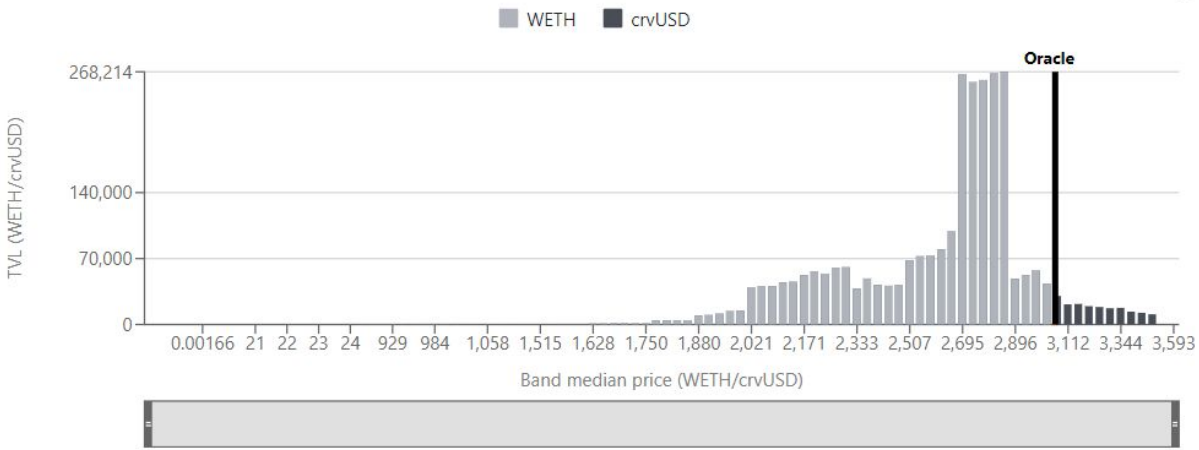


Curve lending on WETH/crvUSD on arbitrum (last week)

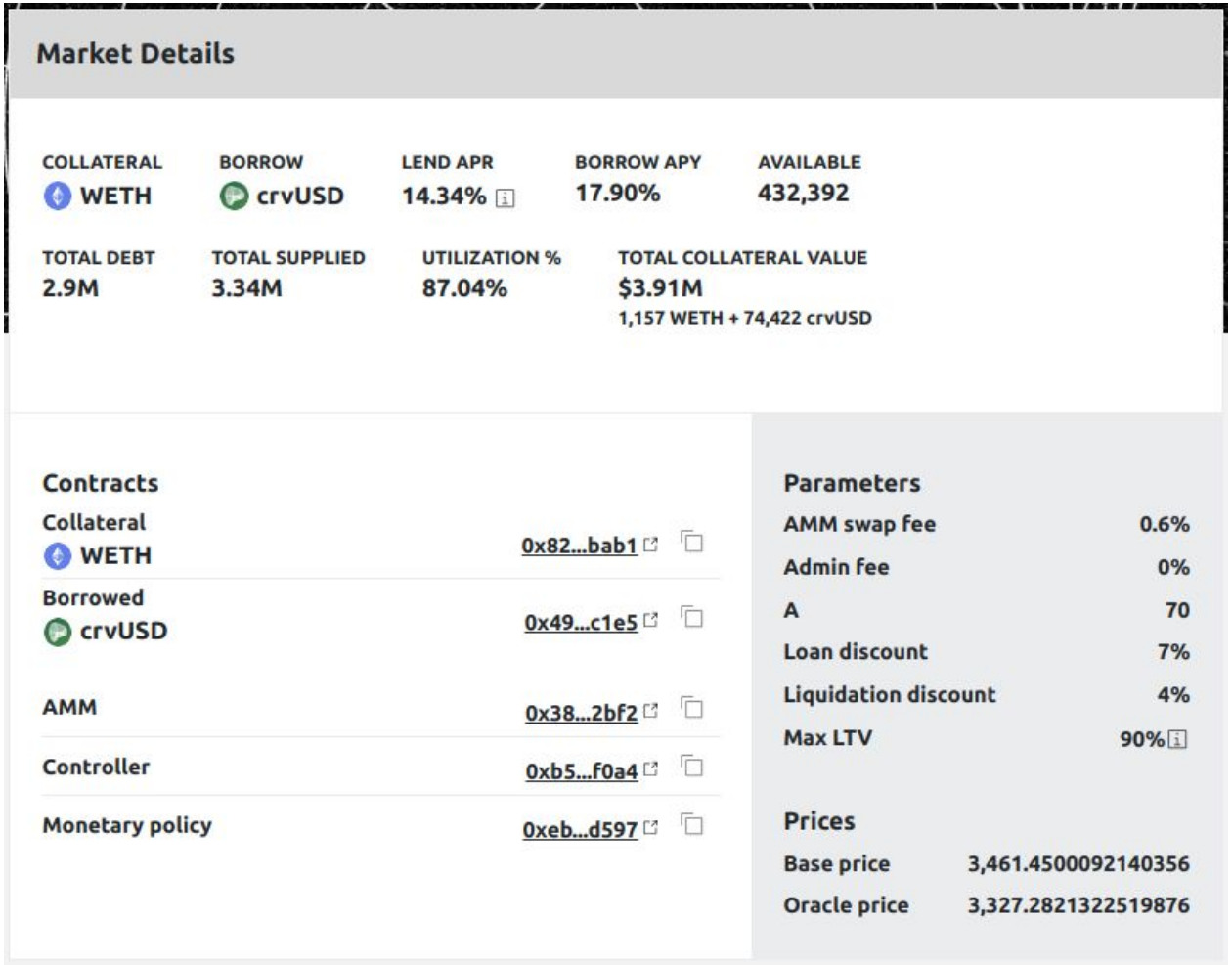
COLLATERAL	BORROW	LEND APR	BORROW APY	AVAILABLE
WETH	crvUSD	8.52%	11.97%	870,712

TOTAL DEBT	TOTAL SUPPLIED	UTILIZATION %	TOTAL COLLATERAL VALUE
2.66M	3.53M	75.34%	$3.40M 1,061 WETH + 175,422 crvUSD

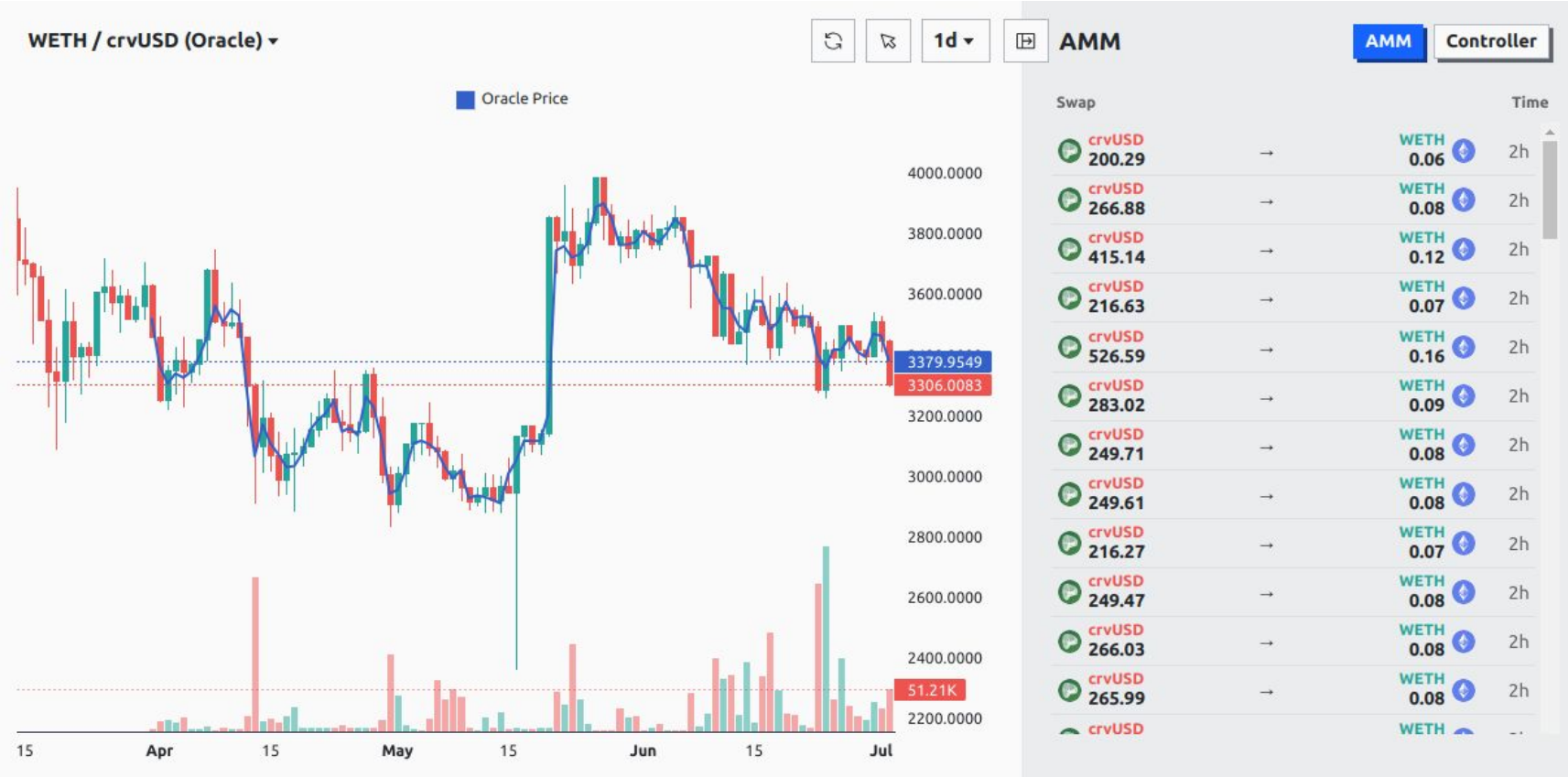
Bands



Curve lending on WETH/crvUSD on arbitrum


Market Details
COLLATERAL
WETH
BORROW
crvUSD
LEND APR
14.34%
BORROW APY
17.90%
AVAILABLE
432,392
TOTAL DEBT
2.9M
TOTAL SUPPLIED
3.34M
UTILIZATION %
87.04%
TOTAL COLLATERAL VALUE
$3.91M
1,157 WETH + 74,422 crvUSD
Contracts
Collateral
WETH
0x82...bab1
Borrowed
crvUSD
0x49...c1e5
AMM
0x38...2bf2
Controller
0xb5...f0a4
Monetary policy
0xeb...d597
Parameters
AMM swap fee
0.6%
Admin fee
0%
A
70
Loan discount
7%
Liquidation discount
4%
Max LTV
90%
Prices
Base price
3,461.4500092140356
Oracle price
3,327.2821322519876

It’s a AMM too!



Arbitrage on price up! crvUSD buys WETH back

Hard-liquidation?

Depending on the health you never get hard liquidated!

If you all your collateral is sold to crvUSD in soft-liquidation, you have crvUSD debt collateralized by crvUSD and all volatile collateral is gone.

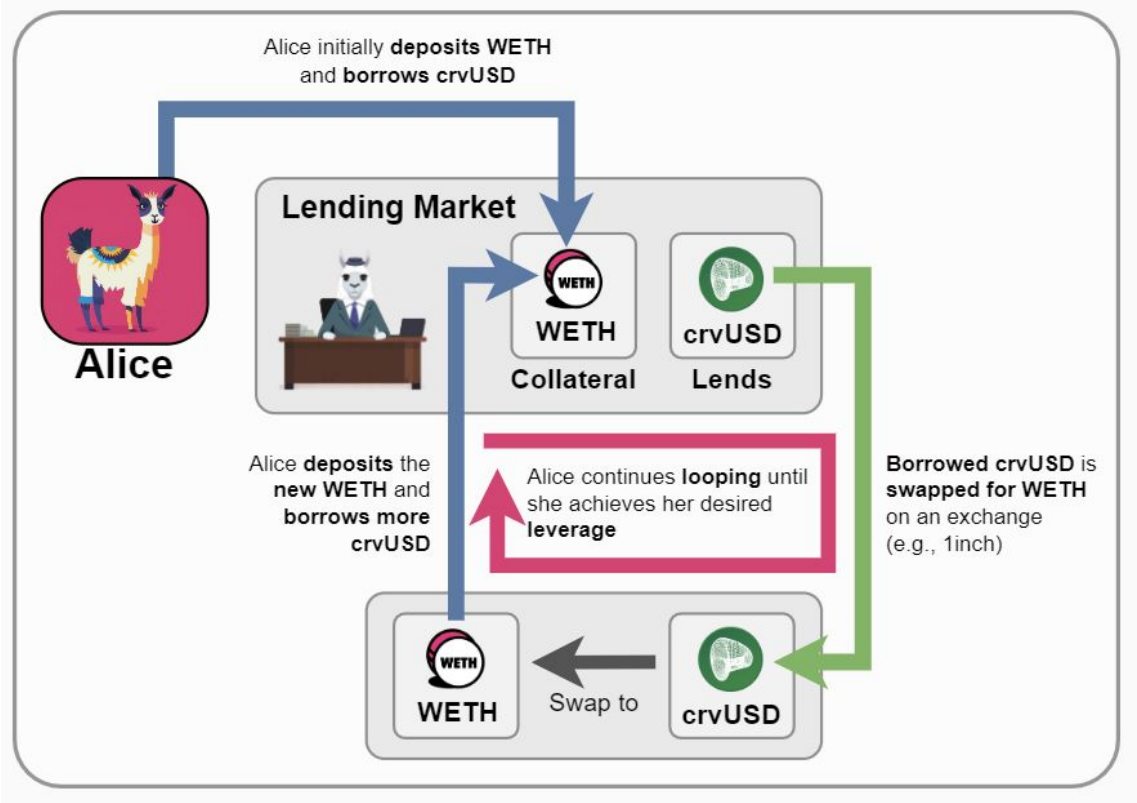
As long as you are fully soft-liquidated, all bands are full with crvUSD, you are save. BUT: Having your bands exposed to a volatile market, your position is de-liquidated and soft-liquidated all the time, as your bands are traded back and forth. This bleeds collateral. And: you are charged the lending rate, which adds do your crvUSD debt.

Strategy: stop loss

Strategy: Curve lending acting as a big stop loss. On price up, you take out more crvUSD.

On price drop, your collateral is sold to crvUSD, backing your debt. If you bands are above the price of the collateral and not traded back and forth you only have to repay your debt to maintain your health, if the market recovers you can self-liquidate and book the gains.

Strategy: leverage



Benefits/Risk for borrowers

Benefits

- Soft-liquidation! Chill on price drops! Long term strategy, sell the top
- Leverage up!

Risk

- Stuck in soft-liquidation in a range
- lose capital because position is sold and bought back all the time.

Benefits/Risk for crvUSD lenders

Benefits

- Isolated risk
- Battle tested contracts
- No fee, just interest rate is market price
- Reward

Risk

- Bad debt if liquidity is thin or on fast price drops

Benefits/Risk for Projects

Benefits

- self listing!
- integrated with aggregators/arbitrageurs and liquidation bots
- users can chill
- integrated with many curve tools

Risk

- Size must be adjusted to liquidity
- needs good price feed, best a curve pool, chainlink is not enough!

Outlook

- We work on a ETH market, currently one of the token the market has to be crvUSD
- More integration and tools build on curve lending
- More chains
- Curve light, AMM side

More info

lend.curve.fi
tg bot @curve_monitor_backup
curvemonitor.com/#/platform/lending
crvhub.com/lending
resources.curve.fi
docs.curve.fi
tg or Discord

Thanks

Saint (Llama) Rat / @saint_rat (Docs/Graphics)
Anon Mo (Docs)
Michael Egorov
All curve contributors

Curve Lending

soft-liquidation for the win!

ethcc7.cryptonative.ch

Questions?