Voting System Anomaly Root Cause Analysis Template v2.0

Root Cause Analysis for:

VV40ECT-130, VV40ECT-131, VV40ECT-132: SCALED BALLOTS CAUSING VXSCAN MISINTERPRETATION OF VOTES - REV. 1
VXSUITE, VERSION 4.0 AND EAC CERTIFICATION #VXS4

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Introduction

This RCA documents three anomalies in ballot interpretation that had a common root cause related to misprinted ballots. The reported anomalies were:

- **VV40ECT-130: System incorrectly reads blank contest as undervote contest**,
- **VV40ECT-131: System incorrectly reads correctly voted contest as overvote contest**, and
- **VV40ECT-132: System overvotes in undervoted contests**

In each case, the reported behavior of the VxScan system was that it incorrectly detected votes on ballot contests, detecting marks in bubbles when there were none, or not detecting marks in bubbles. This also led to flagging some contests improperly as undervoted or overvoted contests. Investigating these root causes was important to verify correct ballot interpretation of the system when ballots are printed according to manufacturer specifications.

Anomaly Description

Complete all sections. Descriptions must be as detailed as possible, while being clear and concise since the anomaly is the source of the entire RCA. This detail should include a complete list and/or description of the "symptoms" of the anomaly and the conditions present which the symptoms occurred.

Date of Anomaly: June 16, 2025	Time of Anomaly: 11:47am
Place of Anomaly: SLI, Wheat Ridge, CO	Person identifying Anomaly: Jessica Myers, VotingWorks
Expected Results of actions leading up to anomaly: Scanning properly printed ballots into VxScan should lead to correct ballot interpretation for all contest types, including N-of-M voting. The system should report only accurate overvotes and undervotes.	

<u>Detailed description of the event / anomaly:</u>

Scanned ballots led to mistallies, detailed in the three cases below.

- VV40ECT-130: A blank contest in the printed ballot (image below, left) led to a single vote tallied in the final tally report (image below, right). Note the margin sizes on the ballot:
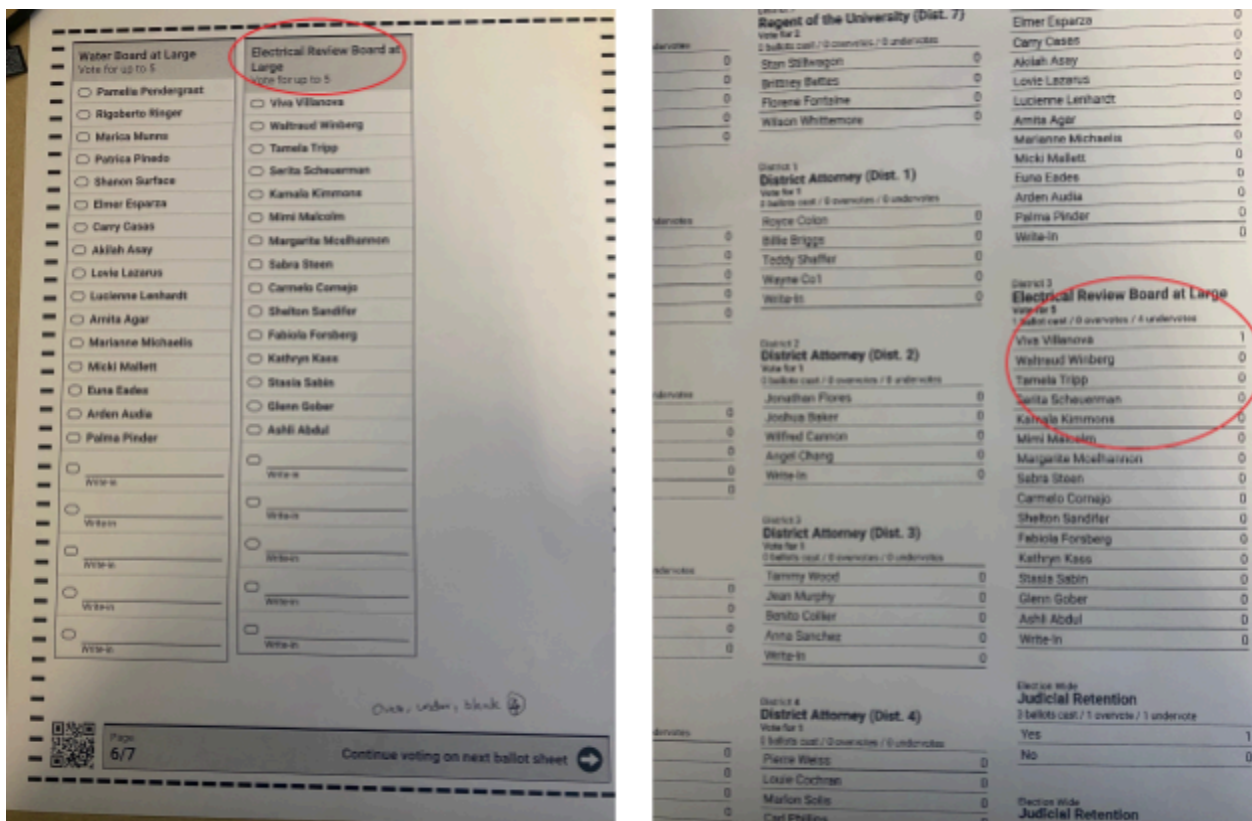
- VV40ECT-131: Correctly voted contests (example ballot in image below, left) were flagged as overvoted contests (image below, right). Note the margin sizes in the example ballot are visibly wider than the timing mark widths:
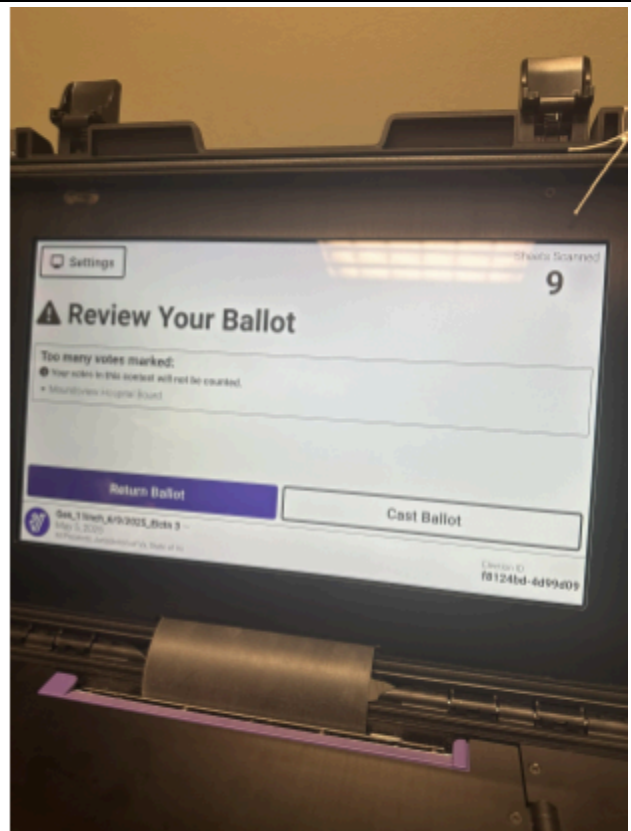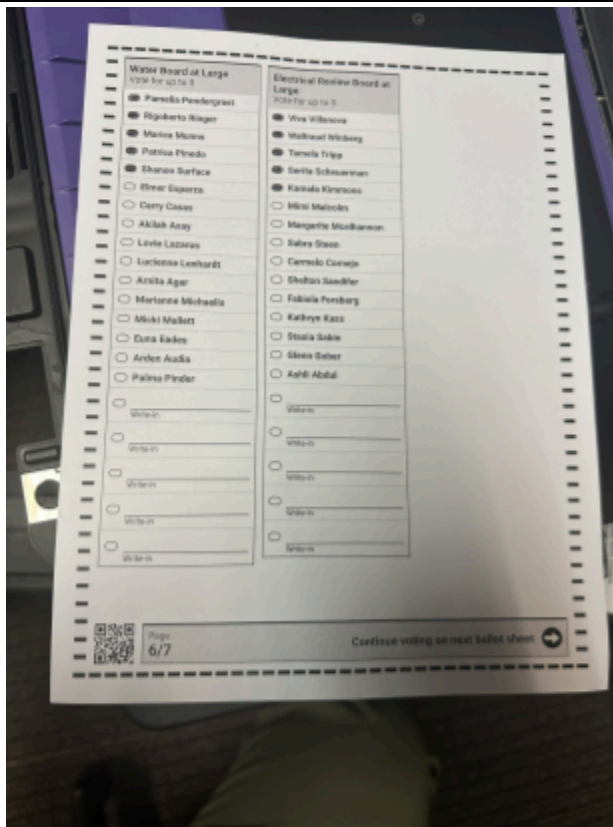
- VV40ECT-132: Ballots inaccurately were reporting extra votes sporadically for some contests. See example blank/unfilled contest (image below, left) and the corresponding tally report showing votes (image below, right). Note the margin sizes on the example ballot:
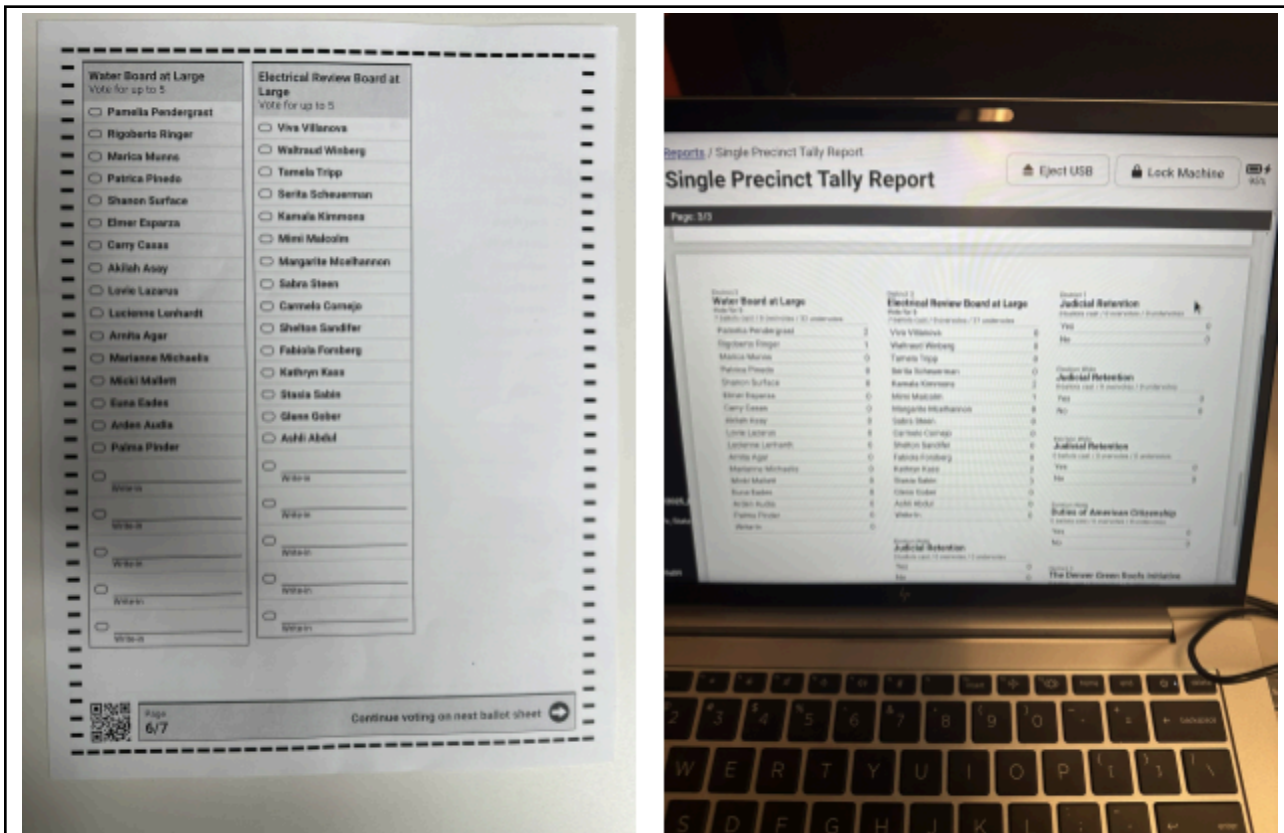
If the anomaly is repeatable, provide step by step instructions to recreate it:

These anomalies are somewhat repeatable, in that the chance of ballot misinterpretation and mistallies increases when printing ballots that are not printed exactly as shown in the ballot PDF output from VxDesign at 100% scale. Examples of such ballots not printed at 100% scale are shown in the photos above. Steps to recreate these prints and associated risk of anomalies are listed below.

1. Use VxDesign to export election packages and ballots.
2. Print the ballot PDFs **not** at exactly 100% full scale. For example, print at 97% scale or smaller, or print with the "Fit" setting instead. Smaller scale out of the 100% specification will increase the chance of the misinterpretation anomalies.
3. Mark the ballots with a known pattern.
4. Configure VxScan and VxAdmin properly with the election packages.
5. Scan the printed ballots in VxScan and observe any warnings that come up, or observe the vote tally reports, looking for anomalous mistallies.

Rescanning a misscaled ballot multiple times may not lead to the same mistally for every scan, however. Several scans should be done to see the increased chance of mistallies when printing at less than 100% scale.

Chronology of Events / Timeline

Provide a detailed chronology of the events leading up to, and following, the anomaly. Add additional events if necessary.

ID	Date/Time	Description	Entity Org/person	Result / Notes
1	6/16/25, 11:47am Eastern Time	SLI reports anomalies with ballot interpretation to VotingWorks. VotingWorks analyzes the details.	Jessica Myers, Drew Hayes, VotingWorks	Several anomalies were reported with different ballot contests, with SLI providing corresponding photos of ballots, VxScan screen warnings, and tally reports. These ballots were printed with the VxAdmin printer. VotingWorks team members noted that these mistallies are known to happen when scanning improperly scaled ballots. Discussions with SLI suggested reprinting ballots at 100% full scale as intended for the sysstem.
2	6/17/25	SLI reports that printing ballots at 100% full scale resolved the anomalies.	Jessica Myers, VotingWorks	100% full-scale printed ballots solved the issues. Some questions arose because some improperly scaled ballots (e.g. printed "to fit") sometimes can scan without any problems and only show issues on repeat scans, depending on very slight differences in paper positioning in each scan. Print scaling between 95-99% may inconsistently show interpretation anomalies, as they often scan properly even if out of spec. However 100% scale is still intended, so as to eliminate these issues.
3	7/2/25	VotingWorks starts implementing software safeguard to react to misprinted ballots with too small a scale	Brian Donovan, Arsalan Sufi, VotingWorks	Associated pull request linked here: https://github.com/votingworks/vxsuite/pull/6710 Work continued following this date to iterate on the feature and verify the software changes.

Investigative Team and Method

This section shall describe how the investigative team is assembled by the voting system manufacturer, who it consists of, and how it gathers the data to be used in the analysis. Include the RCA method employed by the manufacturer in conducting the analysis and why this method was used.

Names and Positions of members of the investigation team:
Jessica Myers, Head of Compliance
Drew Hayes, Product Manager
Arsalan Sufi, Head of Software
Brian Donovan, Software Engineer
Describe the data gathering process: Jessica Myers initiated the investigation upon receiving the information from SLI. She coordinated discussions with VotingWorks, working with Drew Hayes to review known issues with downscaled ballots leading to the behaviors that SLI observed in VVECT-130, -131, and -132. Drew also reproduced the issue when printing ballots "to fit" instead of at 100%. Jessica worked with SLI as they further confirmed that printing ballots at 100% scale resolved the anomalies. Although print specifications address the issue, Brian Donovan and Arsalan Sufi added additional protections in the software to stop and warn users from scanning misprinted ballots that are scaled down.

Describe which methodology(s) is used to conduct the root cause analysis:

The investigation started with a "Five Why's" strategy, asking first for all the known causes of sporadic ballot misinterpretation as seen in the reported anomalies. VotingWorks staff fairly quickly recognized the printed ballots as having wider margins than normal, which previously resulted in the same behavior during development when scanning downscaled printed ballots. This was part of the reasoning for setting a documented specification to print ballot PDF files as-is at 100% scale.

This cause was investigated in detail first by retesting ballots printed at 100% scale and less than 100% scale, both at VotingWorks and at SLI. Other possible causes, such as dirty scans or hardware/software issues, were less likely based on the known data, and would only be investigated if this first cause of misprinted ballots was ruled out. Instead this root cause was confirmed.

Ultimately this led to extended questioning of how else to prevent this issue besides in ballot printing specifications. That led to adding additional guardrails in the software against scanning scaled-down ballots.

Findings and Root Cause

Describe the findings of the investigation and explain the root cause(s) based on these findings. If the RCA results in findings that are not directly related to the root cause of the anomaly, these should also be captured as manufacturer product/process improvement steps in an effort to improve the voting system.

The root cause of each of the anomalies was scanning of ballots printed at too small a scale, less than 100% of the original ballot file PDF produced in VxDesign. This was verified by reproducing the issue at VotingWorks with different ballot scales and also retesting ballots printed at 100% scale at SLI. Scanning 100% scale ballots resulted in no misinterpretations as expected.

One factor that could cause confusion is that misprinted ballots that are scaled down do not all behave the same:
- >97.5% and <100%-scale ballots have not been observed to cause misinterpretation problems, despite being out of specification.
- <97.5% scale ballots inconsistently show interpretation problems. Very shrunken ballots will not scan at all, while 95-97%-scale ballots only sometimes cause problems.
- Ballots printed "To Fit" or with a similar setting scales down ballot sizes differently for different printers, but often at <97% scale. These ballots will then also have misinterpretation issues inconsistently.

Misprinted ballots at about 95-97% scale sometimes scan well without any interpretation issues, depending on the bubble positions. Also slight variations in how the same ballot is inserted in the scanner can influence whether these downscaled ballots will result in misinterpretation, or if a mark is incorrectly detected in the wrong place. Downscaling a printed ballot only increases the *risk* of ballot misinterpretation, but it does not always guarantee misinterpretation. So initially, it was reported that ballots printed at both "100% custom scale" and "Fit" scales were scanned correctly, leading testers to rule out scaling as a root cause and instead look to ballot design settings. However, greater numbers of scans at these different scales showed that 100% scale works as intended, while scales less than this (including "Fit" scale) sometimes causes interpretation problems.

Corrective Action(s)

Corrective actions fall into two categories: (1) instructions and documentation, and (2) additional software guardrails.

Instructions and Documentation

The public documentation for the VxScan system clarifies the requirement to print ballot PDFs at 100% scale (see link: https://docs.voting.works/vxsuite-tdp-v4/readme/ballot-interpretation). This prints the files as their actual sizes, without downscaling. The edges of the ballot PDF files should match up with the physical edges of the printed paper.

If users are printing ballots individually, for example for use during testing or on a printer provided by VotingWorks, then they must ensure prints are at 100% scale. The specific steps for doing this vary according to the user's operating system, PDF software, and printer, but sample instructions are as follows that VotingWorks can customize and provide as needed:

- Do **not** use settings such as Fit to Page, Shrink to Fit, or Scale to Fit, because these can change the actual printed dimensions and margins from the desired 100% scale.
- In Windows, using Adobe Acrobat Reader (or similar PDF viewer):
    - Open the PDF.
    - Select File > Print.
    - In the Page Sizing & Handling section, choose Actual Size or Custom Scale 100%. Do **not** select Fit or Shrink Oversized Pages.
    - Confirm your printer and page settings, then click Print.
- In MacOS, using Preview:
    - Open the PDF.
    - Select File > Print.
    - In the Print dialog, look for the Scale field.
    - Set Scale to 100%.
    - Ensure the option Scale to Fit is **not** selected.
    - Click Print.
- ChromeOS, using Chrome PDF viewer:
    - Open the PDF.
    - Press Ctrl + P, or select Print from the menu.
    - Under More settings, find the Scale option.
    - Select Custom and enter 100. Make sure Fit to Page is **not** selected.
    - Click Print.

Software Guardrails

The VxScan software was also updated to add in another layer of protection in case users go against print specifications for 100% scale and instructions from VotingWorks. The software detects the print scale of scanned ballots based on timing marks. If the scale is detected to be too small, then VxScan rejects the ballot and gives a warning indicating the problematic print scale.

Solution Management

The purpose of this section is to manage the corrective action(s) moving forward. This should detail all process changes to manage those corrective actions, and steps taken to ensure the actions eliminate the anomaly over time.

Management of the corrective actions took place in two areas:

Documentation and Instruction:
- Public documentation about VxScan was updated to clarify the 100% print scale requirement.
- Training sessions and materials relating to ballot printing will incorporate users' needs for their specific computer systems and printers.

Software Updates:
- The VxScan software was updated in v4.0.3 to detect ballot print scale and react to it through standard iterative development processes, review, and testing. The associated core open source code changes can be seen on GitHub here: https://github.com/votingworks/vxsuite/pull/6710