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Executive Summary

This report summarizes the work of the Town of Amherst Commission on Ranked-Choice Voting, authorized by the Amherst Town Home Rule Charter approved in 2017 and charged by Town Manager Paul Bockelman in a meeting on July 9, 2019. The report provides an overview of ranked-choice voting (RCV), identifies the legal and technical requirements for its implementation in Amherst, describes certain policy considerations, and provides the Town Council with a list of decisions and actions to accomplish an effective implementation of RCV in the 2021 local elections, as mandated by the charter. Note that with the defeat of Question 2 in the November 2020 state election, the implementation of RCV in Amherst will apply only to town elections, not to state or federal elections.

Overview of RCV. Ranked-choice voting allows voters to express multiple, ranked preferences among candidates for elected office. Unlike traditional plurality voting, which requires voters to express a preference for only one candidate per seat, RCV encourages a citizen to cast a vote that essentially says, “If my top choice for this position doesn’t win a seat, here’s my second choice, here’s my third choice, ….”

RCV has been used for more than a century in some countries, is being used in some American states and cities, and in Massachusetts has been used in Cambridge since the 1940s. RCV discourages extremism among candidates by providing incentives for consensus-building. In general, it results in winners who enjoy some level of broad support among the electorate.

The implementation of RCV in Amherst, unlike most American jurisdictions using RCV, is complicated by the predominance of multi-winner elections (elections that fill multiple seats of a board, committee, or council) rather than single-winner elections (such as the election of a mayor). The complications—all quite manageable—arise mainly in ballot design and in the calculation of winners from voters’ ranked preferences, topics we address in this report. A substantial voter education effort by the Town will be essential for the success of multi-winner RCV in our local elections.

Legal Requirements. The 2017 Town Home Rule Charter does not by itself provide the legal foundation for changing the Town’s method of conducting elections. The General Court of the Commonwealth of Massachusetts (the state legislature) must also pass a special act authorizing the change. The RCV Commission has worked with the Town Attorney to draft such an act (Appendix 1 of this report) specifying our recommendations for the Town’s implementation of RCV for local elections.

After consulting with the Secretary of the Commonwealth’s Elections Division and obtaining their approval, the Town can finalize various aspects of implementation such as the choice of tabulation hardware and calculation software, ballot design, and security protocols.
**Technical Requirements.** The Town’s current ballot tabulation hardware (the optical scanners used at each poll) will not produce the cast-ballot records required for RCV and must be replaced with state-certified hardware able to produce such records. The RCV Commission understands that the current hardware, already past its projected life expectancy, is due for replacement with or without RCV implementation.

The calculation of voters’ ranked preferences and the determination of winners will be best accomplished with software designed for that purpose. This report describes the limited software options and offers a recommendation.

**Accessibility Requirements.** Voter assist machines (Automarks) are required by state law to ensure accessibility to the ballot. These machines must be programmed in advance of the election and be capable of handling ranked choice ballots if RCV is to be implemented. The Town will need to determine whether the current voter assist machines can be programmed for marking ranked choice ballot; if not, RCV-capable voter assist machines approved by the state must be purchased.

**Policy Considerations.** Just as our past use of plurality block voting reflects certain policy decisions (such as how to count “overvotes,” votes in which the ballot is marked for more candidates than permitted), RCV’s implementation also entails certain policy decisions. For example, if a voter marks more than one candidate at the same ranking, how should the voter’s intent be interpreted and the ballot counted? This report identifies several policy decisions that must be made and offers recommendations for making them.

The method of calculating winners in multi-winner elections must be established based on both policy and technical considerations. The Special Act in Appendix 1 reflects our recommendation for which method to implement.

**Decisions Required of Town Council.** The Commission has identified the following matters as requiring the Town Council’s decisions. For each, we also offer the Commission’s recommendation; however, the Commission recognizes that the Town must assess each of these decisions with regard to factors (such as cost) beyond our purview. We include a calendar with key deadlines for the fall 2021 elections in Appendix 2.

1. **Determine which state-certified precinct tabulators should be purchased to accommodate RCV implementation.** *Recommendation: Dominion ImageCast Precinct Optical Scan Tabulator.*

2. **Determine the method of calculation to be used in analyzing the cast-vote record to arrive at the slate of winners.** *Recommendation: Weighted Inclusive Gregory Method (WIGM).*
3. Determine what computer hardware can be purchased or, if already owned, dedicated to running the calculation software in the Town Clerk’s Office. **Recommendation:** To ensure election security, the computer must meet the criteria described in this report.

4. Determine the central calculation software to be purchased/adapted. **Recommendation:** **Dominion Results Tally and Reporting Software** (we suggest consulting with Easthampton on their choice of LHS and Democracy Suite).

5. Determine whether the Automarks can be programmed to handle ranked choice ballots; if not, purchase state-approved voter assist machines that can.

6. Determine how to establish the security protocols and testing regimen recommended in this report. **Recommendation:** Charge the Town Clerk with drafting the protocols for consideration and approval by the Town Manager.

7. Determine what additional resources, such as infrastructure and personnel, may be required for implementation of RCV. **Recommendation:** Charge the Town Clerk with assessing such needs for consideration by the Town Manager.

8. Determine how to establish an effective voter outreach and education program as recommended in this report. **Recommendation:** Charge the Town Clerk with drafting such a program and timeline for consideration and approval by the Town Manager.

9. Determine the policies to be used in assessing voter intent with regard to:
   - Repeated candidate votes in which a candidate is marked at more than one rank. **Recommendation:** Count the candidate only once at the highest ranking marked.
   - Skipped votes in which some rankings in a race are left blank. **Recommendation:** Move subsequent marked rankings up to fill the blank(s).
   - Duplicate votes (overvotes) in which more than one candidate receives the same ranking. **Recommendation:** Disregard the duplicate candidates and all subsequently ranked candidates.

10. Submit the Special Act to the General Court for enactment. **Recommendations:** Work with the Town Attorney in approving the language provided in Appendix 1. Work with the Town Attorney to coordinate implementation plans with the Office of the Secretary of the Commonwealth, Elections Division. Lobby local legislators and other pivotal legislators to promote passage of the Special Act.

11. Establish a detailed RCV implementation plan, including a timeline for the most critical elements. **Recommendation:** Charge the Town Manager with developing such a plan for review and approval by the Council.
Section 1. Summary of the RCVC’s Charge and Work

The Ranked-Choice Voting Commission (RCVC) presents this report to the Amherst Town Council to fulfill its charge, as described in Section 10.10 of the 2017 Amherst Home Rule Charter, to propose a measure to adopt and implement ranked-choice voting in Amherst. The original deadline of September 1, 2020, was extended to December 1, 2020 per Town Council Order #FY21-26, due to the impact of the COVID-19 pandemic, which prevented the commission from meeting March through July of 2020.

The committee first met on July 9, 2019, and met a total of 23 times (in person and by video conference) to learn the necessary background on ranked choice voting (RCV), explore existing methods for calculating RCV outcomes, develop an implementation plan, identify issues of concern, and write the final report. We gathered extensive information via the web, with each member assigned to research different jurisdictions currently using RCV. To educate Amherst voters about the anticipated change to RCV, we organized two candy votes (mock elections in which voters ranked different candies), at the Amherst First Day Celebration in August 2019 and at the Amherst Block Party in September 2019. We met twice with Town Attorney Lauren Goldberg to gain a better sense of the scope of our committee’s mission and the issues in getting RCV approved by the State, including a Special Act to be approved by the legislature. We spoke on the phone with officials in several jurisdictions and municipalities, including Minneapolis, San Francisco, Cambridge, Takoma Park, MD, Telluride, CO, state of Maine, and Portland, ME. Minneapolis is one of the rare places in the US that uses multi-winner RCV in the form that Amherst needs; we video-conferenced with Aaron Grossman, an elections official from Minneapolis, who demonstrated how their RCV calculations are carried out. We met with representatives of Voter Choice MA, including someone closely involved with Easthampton’s RCV effort, and talked with local experts on historical and political aspects of RCV. We studied tabulation methods, ballot design, common voter errors, and voter education techniques. Through communications with the ES&S and LHS reps, we learned about issues surrounding voting machines and the specific capabilities of the two voting machines that support RCV and are approved by the state. In this report, we document what we learned and our recommendations to the Town for moving forward with RCV.
Section 2. What is Ranked Choice Voting?

Section summary: This section provides an overview of what ranked choice voting is and its general advantages and disadvantages in general as well as those specific to Amherst local elections.

Section 2.1 Overview of Ranked Choice Voting

Ranked choice voting (RCV) is a tested and accepted voting method that has been used in a number of jurisdictions across the United States and internationally for over a century. For elections with a single seat in contention, such as for president or mayor, ranked choice voting allows voters to indicate first, second, and subsequent choices on their ballot, rather than only a single choice. If a voter’s first choice is eliminated from contention, their vote can be transferred to their next choice. Promoters of RCV cite the method’s effectiveness in reducing the influence of spoiler and extremist candidates on election outcomes and in allowing individual voters to express more nuanced preferences among candidates. RCV can encourage more positive campaigning (as candidates avoid alienating their opponents' supporters in hopes of winning their second-place vote), reduce splitting of votes among similar candidates, increase the probability of the winning candidate being elected by a majority, encourage more honest voting without fear of wasting your vote, and improve diversity of representation.

Single-winner RCV has been approved or used for federal and local elections in Maine, and for local elections in many municipalities, including San Francisco, Oakland, New York City, and Easthampton, MA. This year, for the first time, Alaska, Hawaii, Kansas, and Wyoming used RCV for their Democratic presidential primary elections. In addition, RCV has been used extensively in Australia and Ireland, for the Academy Awards, and even by Amherst College for the selection of their mascot, the Mammoths, in 2017.

Multi-winner RCV elections, also known as “single transferable vote,” can be used when there are two or more seats to fill, as is the case with most of Amherst’s local election contests. Multi-winner RCV has been approved or implemented for local elections in Minneapolis, St. Paul, and Eastpoint, MI. Cambridge, MA has been successfully using multi-winner RCV since 1941 to elect their city council. The multi-winner RCV procedure is more complicated than for single-winner elections, with different tabulation rules available, as described in Section 4. A worked example is provided in Appendix 10, and a link to a video with a demonstration of multi-winner RCV can be found in Appendix 7. Major advantages of multi-winner RCV include more proportional representation of the voters, greater incentive to vote sincerely rather than strategically, and reduction of wasted votes.

For a detailed list of municipalities using single and multi-winner RCV, see Appendix 4.
Section 2.2 Arguments for RCV in Amherst

RCV enjoys wide support in Amherst. Despite losing statewide, Ballot Question 2 in the November 2020 election, which would have established RCV for some statewide elections was approved by 76.5% of Amherst voters.

Amherst’s local elections are largely multi-winner contests, including electing two councilors per district and three at-large councilors, to form the 13-member Town Council. The current system of plurality block voting, in which voters approve multiple candidates rather than rank them, can lead to less representative outcomes than a multi-winner RCV method. Consider the following two examples.

Example 1. Suppose four candidates, Alicia, Beth, Caleb, and Daniel run for the two Town Councilor seats in a district. Suppose that, of the 500 voters in this district, 245 vote for Alicia and Beth, and 255 vote for Caleb and Daniel. Under Amherst’s current voting system, in which voters get to approve up to two candidates in this contest, Caleb and Daniel would then win the election, being the two candidates with the greatest number of votes. This outcome leaves nearly half of the voters unrepresented. Under RCV, one candidate from each pair in this example would win —whoever had the most first place votes from each set of voters, as illustrated below — leading to better representation on the Town Council for all voters in this district.

Example 2. RCV can also reduce problems with vote splitting, by providing a method that tends to consolidate votes among voters with similar preferences. Adapting the example above, suppose that, of the 500 voters in this district, 245 strongly prefer Alicia and Beth, while 255 would be happy with any of Caleb, Daniel, and Elena representing them. Note that each voter must choose at most two candidates to mark on their ballot under the current system. Suppose 245 vote for Alicia and Beth, 160 vote for Caleb and Daniel (though they also like Elena), and 95 vote for Daniel and Elena (though they also like Caleb). Under Amherst’s current voting system, Alicia and Beth would win the election, being the two candidates with the greatest number of votes, even though they were supported by fewer than half of the voters. Under RCV, a more representative outcome would occur by consolidating support for the strongest candidate from
each group of voters, as shown below. Note that with RCV, voters can rank as many or as few candidates as they support, not limited to the number of seats.

For other concerns about the current voting system in local elections, see the opinion piece that appeared in the *Amherst Bulletin* before the November 2019 local elections: https://www.amherstbulletin.com/Columnist-Jim-Oldham-29790301.

**Section 2.3 Arguments Against RCV in Amherst**

Both the casting of votes and the calculation of winners and losers are less easily explained with RCV than our current plurality block voting. Therefore, RCV will require substantial voter education to ensure voters understand how to fill out the ranked choice ballot and how the results are calculated. Reporting the election results will be considerably more complicated and may require more time than the straightforward plurality block voting method (which provides a direct count of how many voters approved each candidate). The statewide ballot measure for RCV may partly have failed for this reason.¹

There will also be a need for substantial training of election staff and development of new procedural materials for running local elections. The ballot is likely to be longer, possibly multi-page, and will take longer to fill out; a longer or multi-page ballot may also complicate absentee and mail-in voting. Transparency in how results are calculated and clear communication of what happens in each round of the calculation are essential to gain trust in the new system. It may take

longer to scan in the ballots and longer to determine results, as calculations cannot be done at the precinct level. A particular issue with RCV is that recounts can be complicated and time consuming. Its use may result in legal challenges as possibly violating “one person, one vote.” Use of RCV also restricts options for precinct tabulators to those able to scan ranked choice ballots, and requires software able to calculate results according to the Town’s desired RCV method. The Town’s current voting equipment would not support an RCV election.
Section 3. Amherst-Specific Implementation

Section summary: This section covers several issues that the Town of Amherst will need to consider in the switch to RCV, including how the ballot appearance will change, how ballots are tabulated on election day, how the election results are calculated, and whether preliminary elections are needed.

Section 3.1 Ballot Design

In Amherst, four of the five municipal elections are for more than one seat. Per the 2017 Amherst Home Rule Charter, RCV would be used for the following elections every two years:

- Town Council (thirteen members: two from each of the five districts and three at-large)
- School Committee (five members)
- Library Board of Trustees (six members)
- Housing Authority (three elected members)
- Oliver Smith Will Elector (one seat)

Our current system is plurality block voting; in each contest, voters may approve as many candidates as they like, up to the number of open seats. Implementing RCV in Amherst would mean several changes to our current voting system.

The ballot will have a different appearance and voters will complete it in a different manner. For example, see the portion of the actual ballot from the November 2019 contest to elect five school committee members:

![SCHOOL COMMITTEE ballot example](image-url)
In contrast, below is an example of how that part of the ballot might look under the RCV system (for a full sample ballot, see Appendix 3). The voter will be asked to rank as many candidates as they wish by filling in one oval per column.

<table>
<thead>
<tr>
<th>Candidate</th>
<th>1st Choice</th>
<th>2nd Choice</th>
<th>3rd Choice</th>
<th>4th Choice</th>
<th>5th Choice</th>
<th>6th Choice</th>
<th>7th Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>KATIE LAZDOWSKI</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>BENJAMIN JOSEPH HERRINGTON</td>
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<tr>
<td>PETER M. DEMLING</td>
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<td>7</td>
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<tr>
<td>KERRY A. SPITZER</td>
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<td>6</td>
<td>7</td>
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<tr>
<td>ERIC T. NAKAJIMA</td>
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<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
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<tr>
<td>LAUREN MILLS</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>ALLISON BLEYER MCDONALD</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>(Write-in)</td>
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<td>4</td>
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<td>(Write-in)</td>
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**Section 3.2 Tabulation of Ballots**

The process of ballot tabulation and calculating the results would change. Tabulation of cast ballots would still occur at the polls, early-voting sites, and Town Hall. However, calculation of the results must be done centrally, once all of the ballots are received and recorded; no results will be available at the polls upon closing. Instead, the memory sticks with the Cast Vote Records produced by the tabulators will be physically transported to a central location where the results will be calculated on a Central Results Calculator.

**Section 3.3 Calculation of Election Results**

Calculating the results for the Oliver Smith Will Elector will be done using a standard RCV algorithm for single-winner elections. Calculating the results for the multi-winner contests will require a more complex algorithm as described in Section 4. Because the calculation process is more complex than is used currently and will be done centrally, we expect that the results will not be available as quickly as they are now. However, given the small size of Amherst, we hope that the Town Clerk could still release the preliminary results for most contests on election night.
The town does not currently own voting machines that have the capabilities necessary to implement RCV, so new tabulators, a Central Results Calculator, and appropriate software will need to be purchased or leased. As the Town has been planning to purchase new machines in the near future, the RCV requirements can be folded into the considerations for choosing the new equipment.

We talked individually with election officials from other towns that have used RCV for local elections, including Telluride, CO, and Tahoma Park, MD, as well as reading post-election analyses from cities such as Santa Fe, NM, and St. Paul, MN. One of the main points they highlighted was that voters quickly learn how to fill out the RCV ballot, especially with good outreach efforts that include informative videos. However, voters are often confused by the transferring of votes in the 2nd round and beyond, so much of the education effort needs to focus on explaining how election results are calculated.

**Section 3.4 Preliminary Elections**

If the number of candidates running in one of the local elections is considered too large, it may be desirable to run a preliminary election to reduce the number of candidates, according to some rule such as no more than the greater of four candidates or double the number of contested seats. The Town should determine under what conditions, if any, preliminary elections may be held. One of the benefits of RCV is that it may not be necessary to reduce the slate of candidates to have an effective election outcome. If the Town implements RCV for all local elections and decides that preliminary elections should be held under certain circumstances, then the preliminary elections should also be run using RCV.
Section 4. Calculation Methods for Ranked Choice Ballots

Section summary: Local elections in Amherst will require a multi-winner RCV method, for which there are several different methods available. In this section we evaluate these multi-winner methods according to a set of criteria and then make a recommendation based on that analysis.

Section 4.1 Description of Multi-Winner RCV Calculation Methods

The key process in multi-winner RCV, as Amherst would use for local elections, is the transferring of votes from eliminated candidates and of “surplus votes” for winning candidates, that is, votes for that candidate above the threshold number needed to win a seat. For example, as shown in the graphic below, in the first round the eight surplus votes would be redistributed to next ranked candidates. In the next round, if no further candidate attains the threshold, the candidate with the smallest number of votes would be eliminated and those ballots redistributed to their next ranked candidate.

This redistribution is necessary to reduce the number of wasted votes and to reduce the influence of spoiler candidates, who aren’t likely to win a seat but can tilt the election away from the most popular candidate under plurality systems. However, redistributing surplus votes turns out to be a somewhat complicated task, with several different options available for multi-winner RCV, as described below. While some methods are more advantageous than others, according to the criteria we set out below, the literature on social choice and electoral methods finds fault with every system yet devised, sometimes making statistically fine distinctions and highly nuanced arguments. Despite their limitations, these multi-winner RCV methods for the most part produce more representative and fair outcomes than plurality voting. So, the question is not whether any particular method is perfect, but how well each method satisfies our four criteria:
1. Does it comply with all applicable legal requirements and can it meet Massachusetts certification requirements?
2. Is it adequate to reflect the electorate’s preferences?
3. Can it be clearly and succinctly explained to the electorate?
4. Would it enjoy the electorate’s confidence in outcomes?

Calculation methods for multi-winner elections are considerably more complex than for single-winner elections. The Commission considered these five methods:

- Random selection of ballots for redistribution
- Gregory method
- Inclusive Gregory method (IGM)
- Weighted Inclusive Gregory Method (WIGM)
- Meek’s Method

All five methods take into account the order of preference expressed in cast ballots, eliminating non-viable candidates through one or more rounds of counting, redistributing to the remaining candidates the secondary and tertiary preferences from those ballots on which the eliminated candidate was the first preference. All methods also redistribute, in order of preference, the surplus votes of a candidate who has been “elected” in a multi-winner election. These iterative rounds of counting continue until all seats have been filled.

The development of each method of redistribution of surplus ballots has attempted to get closer to accurately reflecting voter intent. In this context, a candidate wins a seat upon reaching the threshold number of votes, and all votes received beyond that threshold are surplus, available to be redistributed to the other candidates based upon the next preference expressed on each individual ballot. The actual calculation of the threshold is a bit more complicated, but roughly speaking, the threshold is described by the following formula:

\[
\text{Threshold to win a seat} = \left\lfloor \frac{\text{Total number of votes}}{\text{Number of seats}+1} \right\rfloor + 1 ,
\]

where the brackets denote rounding down. For example, if two seats for Town Council are to be filled in a district in which 2,000 votes are cast, the threshold would equal: \( \left\lfloor \frac{2000}{2+1} \right\rfloor + 1 = 666+1 = 667 \).

The Random Selection Method, used by the City of Cambridge since the 1940s, takes a random sample of ballots cast for a candidate who has met the threshold and uses that sample to determine secondary preferences expressed on those ballots; those preferences determine the redistribution of surplus votes to other candidates who have not yet reached the threshold. This method assumes that the random sample will more or less reflect preferences voted across all
ballots, and as the sample sizes shrink, the assumption of accurate reflection of the whole becomes less reliable. In elections seeing relatively small numbers of votes cast and close outcomes, the Random Selection Method undercuts confidence in the outcomes. This method also presents challenges in conducting recounts because the particular ballots chosen for the random sample must have been indexed to ensure that they are the particular ballots used in the recount.

The **Gregory Method** (proposed in 1880 by Melbourne mathematician J.B. Gregory) overcomes some of the shortcomings of the random selection method. The Gregory Method transfers surplus votes by ordering all the ballots received by the top-ranked candidate in Round 1. If the threshold to win a seat is N, then the first N ballots go toward electing that top-ranked candidate. The remaining ballots beyond the Nth one are transferred to their next-ranked candidate. This process continues in subsequent rounds, transferring surplus ballots in this manner. This non-equal treatment of ballots (depending on where in the order the ballot falls) can lead to what the Australians call the “Bonner syndrome,” potentially leading to the “wrong” candidate being elected because subsequent rounds after the first transfer take into account only the transferred ballots, not those held by the candidate in prior rounds. This issue only arises in rare instances in practice, but has occurred on occasion in Australian elections.

The **Inclusive Gregory Method** attempts to solve this privileging of transferred ballots by treating all ballots of a winning candidate the same and by transferring fractional rather than whole ballots. (The term “inclusive” comes from the practice of including all ballots in the process.) That is, rather than look only at the last set of ballots transferred in a round to result in winning, all of that candidate’s ballots will be examined to determine subsequent transfers to the next preferred candidate on each of those ballots, and the value of the fractional ballot transfer will depend on the magnitude of the surplus over the winning threshold. This solves the two deficiencies of earlier methods: the transfer of random ballots and the privileging of transferred ballots over a candidate’s ballots in earlier rounds. But theorists also faulted the Inclusive Gregory Method because the ongoing calculation of transfer values from one round to another or even among different candidates in a single round means that the transfer values of ballots are unequal and inconsistent. So, for example, in the Round 2 of counting, Candidate B may receive transferred votes from Candidate A at a fractional value of 10% because Candidate A had 110% of the threshold. But once round 2 is done, Candidate B actually has 120% of the number needed to win and so transfers votes to Candidate C not at the 10% rate they were received but at 20%. Thus, some votes may actually increase in value across rounds—again, not accurately reflecting the electorate’s preferences.

This variability in transfer values led to the adoption of the **Weighted Inclusive Gregory Method** (WIGM) though many jurisdictions continue to use the unweighted method. WIGM uses all the procedures of the Inclusive Gregory Method except that it avoids the variability in value among redistributed votes from round to round. The means of achieving this more accurate
weighting of transferred votes are technical, but a major feature consists of not transferring any votes to a candidate who has already achieved the threshold even if that candidate is the expressed secondary preference on a ballot available for transfer; instead, the vote goes to the expressed tertiary preference on the ballot. Thus, a candidate meets/exceeds the threshold only once throughout all rounds of counting, and the vote count for a candidate who has reached the threshold remains static through all subsequent rounds of counting.

**Meek’s Method**, developed in the late 1960s but rarely used, is an enormously complicated algorithm that distinguishes itself from WIGM by continuing to transfer votes to and from candidates who have met the threshold. Meek’s Method attempts, through its exhaustive examination of preferences on all ballots, to get as close as possible to a reflection of voter preferences. Its primary—and, in the case of the Town of Amherst, fatal—deficiency is its complexity. Its execution requires software, possibly making a hand recount of ballots impracticable and undercutting confidence in outcomes.

**Section 4.2 Evaluation of the Methods Under the Four Criteria**

We assessed these methods against our four criteria:

1. Does it comply with all applicable legal requirements and can it meet Massachusetts certification requirements?

   All methods are likely to meet legal requirements (though Meek’s method may be more difficult to get approved by the Elections Division, given the lack of software available). Commercially available software has implemented WIGM, making that method the easiest to access. Developing and securing approval of new software for the other methods seems both unnecessary and somewhat risky. The Random Selection Method being used by Cambridge has been approved for use in that municipality due to its first implementation in the 1940s, but it seems unlikely that new uses would be approved.

2. Is it adequate to reflect the electorate’s preferences?

   As described above, the Random Selection and Inclusive Gregory Methods have deficiencies in this respect though both methods continue to be used elsewhere. WIGM and Meek’s Method come closest to reflecting the electorate’s intent.

3. Can it be clearly and succinctly explained to the electorate?

   The Random Selection Method is rather easily explained once the basic concept of transferrable votes has been explained. Meek’s Method defies any such explanation, and WIGM presents challenges. A well-regarded video produced by Minnesota Public Radio clearly and succinctly demonstrates a simplified version of the Inclusive Gregory Method,
and the City of Minneapolis has used that video and other voter-education materials to promote their use of WIGM. The distinctions between IGM and WIGM can be described, but they may be too much “in the weeds” for most voters.

4. Would it enjoy the electorate’s confidence in outcomes?

The Amherst electorate may be better educated and informed than is the case for many comparably populous towns in New England, but with those characteristics also sometimes comes skepticism. The brief history of IGM, WIGM, and Meek’s shows that efforts at better reflecting voter preferences continue to drive refinements to the point that only a miniscule portion of the electorate would understand how outcomes were arrived at, yielding anxiety that outcomes are being determined in a “black box.” Current public skepticism about institutions and prominent examples of technology failures (such as the 2020 Iowa caucus results) cause us apprehension. That said, the confidence of the electorate will depend to a great extent on the Town’s voter education efforts and success.

While the Random Selection Method is the easiest to explain, we believe that any method relying on random selection is likely to face skepticism, especially among voters who understand the problems inherent in random selection in small sample sizes.

Based on our research and the considerations above, between the two methods that meet our criteria (WIGM and Meek’s), we recommend that the Town of Amherst use the WIGM Method, as specified in the Special Act in Appendix 1. This method is being successfully used by the City of Minneapolis and other municipalities with multi-winner elections under RCV.
Section 5. Ballot Errors and Voter Intent

Section summary: Ranked choice ballots are prone to a variety of voter errors, so the Town should set rules for how to interpret voter intent in a consistent manner. Possible errors that voters may make when ranking candidates include ranking the same candidate more than once, ranking more than one candidate for a particular rank, or skipping ranks. We offer recommendations for how to handle each case.

Section 5.1 Descriptions of Ranked Choice Ballot Errors

Because both the ballot itself and the procedure for filling out the ballot are more complicated under RCV than in the plurality block system, we expect that use of RCV may result in more ballots with voter errors requiring interpretation, especially during the first few elections. Some types of errors made by voters on election day at polling places can be identified by the voting tabulator and the voter offered a chance to fill out a fresh ballot. However, voters who vote early, absentee, or by mail will not have this check on their ballots to catch errors, and not all types of errors will be caught by the voting tabulator. Hence the Town will need a protocol for identifying voter intent in a consistent, reproducible manner.

We would like to emphasize the importance of voter education to prevent the following ballot errors and to ensure that voters understand how to properly fill out their ballots to make their intentions clear.

There are four types of ballot errors that we can expect: undervotes, repeat candidates, incomplete or skipped rankings, and duplicate rankings (sometimes called overvotes). How these errors are handled may be constrained by what options the ranked choice voting system chosen by the Town has available. We discuss each type of error below.

Undervotes are defined as a ballot with no rankings at all in one or more races. The ballot is ignored for any such race, just as it would be in our current system.

Repeat candidates are candidates that have been ranked more than once in the same race. For example, a candidate ranked as both 2nd and 3rd on a ballot in the same race, or even marked at every rank, would be a “repeat candidate.” In such cases, the candidate should be counted only once, at the highest ranking that appears on that ballot. Any lower-ranked candidates should be moved up accordingly to fill the ranks now vacated by the repeat candidate, as shown in the following example.
A **skipped ranking** occurs when a voter ranks the candidates but skips a number in the sequence. For example, a ranking of candidates only at 1st, 3rd, and 4th has skipped the 2nd ranking. In such cases, the rankings of the lower candidates should be moved up to make a complete sequence. Thus, in this example, candidates marked 3rd and 4th on the ballot would be instead recorded as being in 2nd and 3rd place, respectively, for purposes of calculating the results.

If there is more than one skipped number in a single race, one option is to discard all rankings below the missing ranks. For example, if a ballot only has 1st and 4th places marked, where 2nd and 3rd places have been skipped, only the voter’s 1st choice would be recorded. The candidate ranked 4th would not be counted because there is a significant chance that the voter intentionally ranked the candidate 4th in order to designate that candidate as a last preference. Despite this possibility, **we recommend that in all cases of skipped rankings, we follow a consistent rule: candidates below the skip(s) be promoted to create a consecutive ranking sequence.** In the example, the voter’s 1st and 4th places would be interpreted as their 1st and 2nd place candidates. Voter education will be important for ensuring the voters understand this point.

A **duplicate ranking** (also called an overvote) occurs when more than one candidate has been given the same ranking. For example, if two candidates are both marked as 2nd place choices, the voter’s order of preference between the two cannot be determined. This is the most difficult error to resolve and there is no universally accepted standard for interpreting voter intent in this case.
Some options for resolving duplicate rankings include the following:

- Cambridge discards the ballot for that race.
- San Francisco records all rankings higher than the duplicate ranking and discards the rest.
- Minneapolis discards the duplicate-ranked candidates but records the rankings above and below. (This may be in conflict with the Amherst Town Charter, which states “a voter’s lower ranked choice is not allowed to impact the likelihood of a higher ranked choice being selected.”)
- Maine, like San Francisco, records all rankings higher than the candidates with equal ranking. In addition, Maine records rankings below those candidates but only counts those rankings if the candidates with equal ranking have been eliminated.

Creative solutions, such as assigning half-votes or applying a tie-breaker to candidates that have been equally ranked are not possible due to the constraints on the tabulators, calculation software, and recount requirements.

To resolve duplicate rankings, we recommend following the San Francisco model of discarding the candidates with equal rankings as well as all candidates with lower rankings than the equally-ranked candidates.

<table>
<thead>
<tr>
<th>Submitted Ballot</th>
<th>Recorded Vote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emily</td>
<td>1st Choice: Emily</td>
</tr>
<tr>
<td></td>
<td>2nd Choice: Helen</td>
</tr>
<tr>
<td></td>
<td>3rd Choice: Julius</td>
</tr>
<tr>
<td></td>
<td>4th Choice: Robert</td>
</tr>
<tr>
<td></td>
<td>5th Choice: William</td>
</tr>
</tbody>
</table>

Section 5.2 Summary of Recommendations for Interpreting Voter Intent

- Each repeat candidate should be counted only once, at the highest ranking that appears on that ballot. Any lower-ranked candidates should be moved up accordingly to fill the ranks thus vacated.
- In all cases of skipped rankings, promote candidates below the skipped ranks to create a consecutive ranking sequence.
- To resolve duplicate rankings, disregard the equally-ranked candidates as well as all subsequently ranked candidates.
Section 6. Tiebreakers

Rules for breaking ties that may occur during rounds of the RCV algorithm should be specified in advance of the election and may not be changed during the course of the election. For example, two or more candidates may be tied for who has the least number of votes when eliminating a candidate in a round where no candidate meets the winning threshold. A tie may also occur when two or more candidates pass the winning threshold by the same number of votes. We recommend basing these determinations on the number of votes each of the tied candidates had in the previous round. RCV software may provide further options for the various situations that arise requiring the breaking of ties in RCV calculations.

Using batch elimination in the first round, that is, immediately eliminating candidates with no chance of winning and redistributing each of those votes to the next ranked candidate, can reduce the occurrence of ties in practice.

For reproducibility in a recount, each tiebreaking event must be recorded during the RCV calculation and reused during the recount. We recommend avoiding random tiebreakers like flipping a coin if possible, to increase the reproducibility and fairness of the procedure.
Section 7. Steps to Gain State Approval of RCV for Amherst Elections

Section summary: The Town will need to work with the MA Secretary of the Commonwealth’s Elections Division to develop an acceptable implementation plan to use RCV in Amherst local elections, including the choice of voting machine, RCV calculation software, recount procedures, and ballot layout. This section briefly outlines some key steps.

Voting Machine Certification. The Cast Vote Record is a spreadsheet or other data file generated by a precinct tabulator containing information on how each ballot was marked. Only the precinct tabulator generating the Cast Vote Record needs to be certified by the state. The RCV software that combines the Cast Vote Records from all of the tabulators and calculates the election results does not, strictly speaking, need to be approved by the state, but we recommend that the Elections Division review it to ensure its suitability.

Special Act. The MA legislature will need to pass a special act allowing Amherst to use RCV in its local elections, similar to what Easthampton recently had passed (https://malegislature.gov/Bills/191/S2331). We have provided draft language in Appendix 1, developed with the assistance of Town Attorney Lauren Goldberg.

The special act should be accompanied by a supporting letter and with this report appended, explaining why Amherst would like to switch to using RCV in its local elections and the groundwork we have already done.

Contacting potentially supportive members of the state legislature, including our own State Representative Mindy Domb and State Senator Jo Comerford, to promote their support of the special act, will increase its chances of passing.

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2 For an example of a Cast Vote Record from a 2017 election in Cambridge, see https://docs.google.com/spreadsheets/d/15nj68t38ydl_zWjtWYbfSmyTSUpYWWOiPKZxxu6y6-4/edit#gid=1174618093.
Section 8. Preparation for Local Elections using Ranked Choice Voting

Section summary: Ensuring a smooth rollout of RCV for Amherst elections will involve multiple preparations, including voter education, staff training, and updating of election procedures, which may require several months. We discuss the different elements of a successful implementation plan based on the experience of other jurisdictions.

Section 8.1 Implementation Plan

Conversion of Amherst elections from plurality block voting to ranked-choice voting will require both short-term and ongoing measures, including voter education, staff training, testing, and adoption of updated procedures, to ensure the integrity of and voter confidence in the electoral process and outcomes. Note that the planning and rollout may require several months. Some U.S. municipalities that have converted to RCV have reverted to their original systems, usually after procedural delays or outcomes raised doubts among voters about the system’s trustworthiness. Conversion will also require the Town to address new demands, which we address below.

Fortunately, several municipalities and advocacy groups have already blazed this trail. For example, the City of Minneapolis, which approved RCV in 2009, created a comprehensive implementation plan:

- In spring 2009, reviewed the newly-created Ranked Choice Voting city ordinance for housekeeping changes needed.
- Determined that the best method to count the multiple seat offices that would comply with Minnesota law was the Weighted Inclusive Gregory Method (WIGM), which could produce the same election results in a recount.
- In May 2009, conducted a "test election" for several purposes:
  - To develop the first-draft ballot design.
  - To user-test different draft versions of materials that would be used by election judges [the equivalent of wardens in Amherst elections] in the polling place to help voters.
  - To invite various groups to experience Ranked Choice Voting & share their feedback on that experience and the ballot itself.
  - To develop the method for hand-counting the single seat and multiple seat offices to determine the winner(s).
- In August 2009, the hand-count process was redesigned. A one-week "work-out" session developed the Minneapolis Method of hand-counting the ballots at the precinct level to use the precinct level data for analysis by office.
The training plan for election judges was designed to use at least one-half of the class time to explain Ranked Choice Voting to the judges.

- Hired an organization to conduct an impartial survey of voters, candidates and election judges concerning implementation.
- Recruited a Historian to document the implementation.
- In addition to traditional precinct staffing, election judges were recruited and scheduled to do counting and data entry.
- In 2014, the City developed a plan that included:
  - Identifying key partners – including internal partners within the city and external organizations.
  - Developing consistent messaging – “YOUR CITY. YOUR VOTE.”
  - Determining outreach methods (see Appendix 7 for some sample resources).
  - Creating education tools – an array of tools to be used and shared in a variety of education efforts.

The efforts taken by Minneapolis may be excessive in the context of a municipality the size of Amherst, but they illustrate the need for a comprehensive and thoughtful approach to implementation. We believe the Town should address each of the following areas of implementation well in advance of the first use of RCV in a local election.

**Section 8.2 Voter Education and Outreach**

Once state and local authorities have approved implementation of RCV in Amherst, a voter outreach effort should begin, using multiple venues and media for educating voters about the following aspects of the change to RCV:

- How RCV differs from plurality or approval voting and why it is being adopted (emphasis on its benefits and the mandate incorporated in the charter approved by Amherst voters).
- How ballots will differ from past ballots (emphasis on visual presentation, illustration of correct ballot marking).
- How the counting and reporting of votes will differ from past elections (emphasis on using redistribution of second- and third-choice votes to reflect the will of the voters).

This outreach effort should make use of existing materials/media where they suffice, such as the video from Minnesota Public Television explaining the redistribution of “surplus votes” to reflect voter preferences. Appendices 5 and 6 offers several examples of such materials.

The effort should also include some simple RCV talking points (perhaps in the form of an FAQ) brief enough to fit on a half-page flyer. Such information can be mailed, emailed, provided to the
Amherst Bulletin and Amherst Media, handed out at town and school events, and, in addition to addressing the top points, should direct those interested to the Town website and Facebook for more information. The website itself can rely heavily on external links to existing sources of RCV information but should also present Amherst-specific information.

In its work, the RCVC set up tables at two town events to share information about RCV and to hold “mock elections” that allowed citizens to rank their favorite candy. The ease with which participants understood the concept was reassuring. While the City of Minneapolis actually conducted a test election as described above, the Town could design a simple mock-election package that strikes a middle ground between candy ranking and a test election. Such a package, which would enable small groups to conduct mock elections independent of any oversight, could demonstrate ballot design, marking, counting, and reporting. The package could use email and online sites for distribution to schools, clubs, senior centers, care centers, and other venues and organizations. In order to inform the next generation of voters, the Town could encourage local schools to employ RCV in student elections.

How to report the election results should also be carefully considered. Some contests may require multiple rounds of the RCV method, with complicated transfers of fractions of votes to next-ranked candidates as some candidates are either elected to a seat or eliminated from contention. Ways to visualize what happened across the RCV rounds in an election to lead to the final result have been developed, for example, http://rcvis.arminsamii.com/. Again, a central objective should be to make the process as transparent as possible and build trust in the system.

Section 8.3 Staffing Considerations

The conversion from plurality voting to RCV will require greater centralization of the tabulation and reporting functions during election periods. The current poll closing procedures will not change significantly except that results will no longer be available at the precinct after closing. Individual precinct cast-vote data will be transferred to a central location for the calculation of vote totals and the winners of individual elections. Because candidates and observers sometimes want to know precinct-level results, the Town should anticipate and plan for the possibility that the absence of such results at the polling stations and the need to transfer data to a central location may cause confusion, even suspicion. The Town should accommodate the observation of the transfer of precinct data to the central location.

At least some poll workers at each precinct will need knowledge of RCV sufficient to explain the basics to voters who are confused by the changed ballot and marking procedures. Currently, wardens and clerks are often fully occupied with resolving voters who are marked as inactive or who must cast a provisional ballot. The Town Clerk should consider training additional poll workers who will be stationed at or near the check-in table to answer voters’ questions.
The Town Clerk’s Office may require additional training for staff who take the Cast Vote Record and process it to report results. The Commission has not yet resolved all questions regarding what software may be used in this process, but to the extent human monitoring and intervention in the process are required, staff will require specialized training. Under Massachusetts law, recounts must be conducted by hand, which might involve use of spreadsheets for calculating the RCV formulas, as has been done in Minneapolis. We recommend that the Town work with the MA Elections Division to optimize the recount procedure. For instance, it may be permissible to build a Cast Vote Record spreadsheet directly using the ballots, and then run the RCV software on that spreadsheet, rather than having to do the calculations by hand. Any staff involved in recounts will require special training, and materials should be developed to clearly lay out procedures.

The Commission does not wish to speculate regarding the potential need for expanding election staff, either temporarily or long-term.

Section 8.4 Testing of Machines

The Town Clerk’s Office routinely tests tabulators before each election to ensure that they remain in working order. The Commission recommends that a more rigorous program of testing be undertaken long before first implementation of RCV in Amherst—far enough before the first-use election to ensure that any problems can be resolved well before the election. Such testing should go beyond the assessment of working order to also determine how the hardware, software, and operators all interact in delivering outcomes that accurately reflect the RCV design.
Section 9. Technical Requirements and Options for RCV-enabled Voting Systems

Section summary: The hardware and software requirements for multi-winner RCV elections are explained, along with the options available to the Town and the functionality needed in each component of the overall RCV voting system. We offer recommendations for which options may best serve the Town.

Section 9.1 Summary of Technical Considerations

Overview of our requirements. Here we will outline the requirements for voting machines, associated software, and some of the considerations we will need to be mindful of when anticipating the inevitability of human error and security needs. For an implementation of RCV in Amherst, we will need Precinct Tabulators (Tabulators), which are the machines located in each precinct that read the ballots and record the voting data, and a Central Results Calculator (CRC) which will take the complete set of voting results from all precincts and calculate the winner of each race. Our requirements for RCV hardware and software fall into four categories: hardware capabilities, software capabilities, security, and ease of use.

Major Changes. In any election there are two parts to the process, the recording of votes and the counting or processing of those votes into a final result. In our current plurality block voting system, the processing of the vote is simple counting and addition, which can be done at the precinct level and/or at a central location. For RCV, the processing is considerably more complex and must be done centrally. The central processing is required both because all recorded votes are needed to run the RCV algorithm and because the software to process the votes will be installed on one secure, central computer. Thus, no partial results can be released before the final results have been completed.

Massachusetts Commonwealth Approved Precinct Tabulators. Hardware and, in some cases software, must be on the MA Elections Division’s list of certified hardware. Taking into account the minimum requirements to run multi-winner RCV elections, our choices are immediately reduced to two sets of hardware– the DS200 from Election Systems & Software (ES&S) and the ImageCast Precinct from Dominion. This requirement also limits our software choices to the software included with the above listed machines, one third-party software option (the Universal RCV Tabulator), and an option using Excel spreadsheets (as Minneapolis has done).

Recommendations. If the town can afford it, we recommend the town purchase the Dominion ImageCast Precinct machine for our precinct level tabulators and use the packaged Dominion Results Tally and Reporting software for calculating the results. If customizability becomes a necessity, we recommend negotiating a contract with either Dominion or ES&S for precinct tabulators and using the Universal RCV Tabulator for results calculation.
Section 9.2 Precinct Tabulator Requirements

Overview. The precinct tabulators, or scanners, are the most familiar hardware to voters. These are the actual machines that ballots are fed into at each voting location, or a centralized location in the case of mail-in ballots. We apply four major criteria of evaluation: functionality, security, auditability, and usability.

Functionality. Tabulators must…

1. Read RCV ballots and produce Cast Vote Records, which are spreadsheets or other data files containing all information on how each ballot was marked.
2. Copy all Cast Vote Records onto a USB stick for physical transfer to a Central Results Calculator.
3. Alert users to potential voting errors (repeated rankings, undervotes, and skipped rankings), and allow users to either override (continue reading the ballot with errors) or cancel (spit their ballot out for revision).
4. Read write-in results and output that data to the Cast Vote Record.
5. Support two factor authentication – something you have and something you know, for example, a physical device and a password.

A note on the issue of write-in candidates: Like our current precinct tabulators, the available Precinct Tabulators that support RCV do not automatically process write-in votes. Election officials must manually process each ballot, read the write-in entries, and record those write-in candidates to the Cast Vote Records. These newer machines can instead take a photo of the write-in field and append it to the Cast Vote Record, so when election officials go to confirm the write-in, they can view an image of the write-in directly in the Cast Vote Record without having to manually refer to the actual ballot. This is an extremely useful and time-saving feature which does not impact election security. However, it is unclear if we can use this functionality given the Commonwealth’s ban on photographing ballots. We believe we can apply for a ruling/exception for this feature since taking a photo of the write-in for use by election officials is not counter to the understood intent of the law.

Security. Security can be divided into the categories of physical access, hardware security, software security, personnel, and logging.
1. Physical Access  
   a. Access to the administrative parts of the machine must be constrained by a physical barrier with a physical locking mechanism. For our purposes, this barrier must be secure enough to prevent clandestine access to the machine while it is in public at the polling place.  
   b. It must be readily apparent, either via a built-in mechanism or an additional mechanism that Election Administrators can apply, when the physical barrier has been tampered with.

2. Hardware Security  
   a. Tabulators must be entirely stand-alone (air-gapped), meaning no network or internet access, period. No physical modem, network card, or other type of communications hardware which would enable the machine to transmit any form of data in any way other than by transfer on a physical drive.  
   b. Tabulators must only accept certified flash drives for updates or with election data. This will serve to prevent unauthorized programs on USB sticks from having access to the machine’s software.

3. Software Security  
   a. Tabulators must have a tiered permission structure which can provide different levels of access to different user roles. As an example, an administrator would have access to all functions, including setting up an election, whereas a Poll Warden may only have access to the functions which start and stop the election, and an Election Worker would only be able to deal with ballot specific errors for a specific ballot.  
   b. Tabulators must log all access to the software on the machine, and all actions taken on the machines.  
   c. Logs can only be deleted by the administrators under specific, desired circumstances.  
   d. Modification of the logs is strictly prohibited.

4. Auditability  
   a. Tabulators must maintain the election results until administrators delete them or a new election is loaded.  
   b. Cast Vote Records generated by the Tabulators after all of the votes are cast must be digitally signed to allow for cross checking data integrity at the Central Results Calculator (CRC). Digital signatures are similar to physical signatures but are much more secure – they allow us to verify that the data we are processing on the CRC came from specific Tabulators used during the election.  
   c. Tabulators must maintain a record of election results as a secure backup and for cross-reference for a length of time mandated by the Commonwealth.

5. Usability  
   a. Ideally, election workers with minimal training should be able to perform all required actions rapidly and without difficulty on the chosen tabulator.
Section 9.3 Central Results Calculator

Requirements. The Central Results Calculator (CRC) is software that runs on a standalone computer; it compiles the results from all the precincts and uses that data to calculate the result of the election. In plurality and approval voting, election officials simply need to add the vote tally from each precinct together, which can be handled by a calculator. In RCV we need to calculate the results in several rounds, which is a complex process requiring its own software running on either proprietary hardware or a securely setup off-the-shelf computer. There are inherent difficulties in creating a detailed list of security and auditability requirements for the CRC because solutions vary significantly in both hardware and software. As such, the items listed below will be considered a baseline for effective security for any solution.

Security. There are two major security considerations. First, the CRC must be stand-alone (air-gapped) either entirely, or at the time of the election, following the MA Elections Division’s guidelines. In particular, there should be absolutely no network access: network hardware must have either been removed or sufficiently disabled. Second, there should be a tiered permission structure which can provide different levels of access to different user roles.

Auditability. The CRC must have audit logs recording log-ins and actions taken on the computer, both within the larger operating system, such as other applications run and files opened, as well as any action taken within the CRC software itself.

Section 9.4 Process Requirements

Security of Precinct Tabulators and the Central Results Calculator. There is nothing inherent to RCV Tabulators which requires extra security at the precinct level over what we currently have. The computer we use for the CRC must be treated like any other voting machine, and must be kept physically secure during setup, the election, and results tabulation. As such, requirements for this machine will be similar if not identical to those used for Precinct Tabulators.

Security of Data Transfer from Precinct Tabulators to the Central Results Calculator. Under plurality voting, the processing of votes is much more transparent with many obvious redundancies built into the system. Precinct tallies can be communicated by phone and/or physically delivered on a results sheet printed by the Precinct Tabulator to the Town Hall. There are very few, if any, opportunities for tampering which have not already been accounted for and addressed by state and federal best practices, procedures, or law. In RCV, there is a large quantity of data from each Precinct Tabulator that must be transferred to the Central Results Calculator safely and securely before any results can be calculated. We must pay special attention to make sure the process is both secure and transparent to maintain election security and ensure public confidence.
We recommend the following election procedures concerning the CRC:

1. Tabulator data will be exported onto a USB stick that has been approved by the company providing the hardware/software and by the MA Elections Division for security purposes.
2. The USB stick must be physically transported to the CRC location by an appropriately appointed official. Ideally multiple people will be involved in the transfer. Current policy should inform this decision, but we should acknowledge that this information is more sensitive than what is currently transferred, since Cast Vote Records in transit are potentially vulnerable to manipulation in ways that vote tallying under plurality and approval voting are not.
3. The CRC should have some method of validating that the USB sticks with the Precinct Tabulators come from legitimate Precinct Tabulators. This will help ensure that if the Cast Vote Records were tampered with in transit between the Precinct and the CRC, election officials will be able to detect that tampering and acquire a new copy.

**Current Hardware.** Amherst currently uses Accu-Vote tabulators. These machines do not support RCV, and so are unsuitable for our needs. As they are older tabulators and near or past their expected end of life, the Town of Amherst has been looking to replace them.

**Precinct Level Options.** The two options we have for tabulators which fulfill our requirements, listed above, and those of the Commonwealth are the DS200 by Election Systems & Software, and the ImageCast Precinct by Dominion and fulfilled via their local vendor LHS. LHS is our current vendor for Accu-Vote machines. Instead of breaking these machines down point by point, we will simply state up front that these machines are both very similar. They both fulfill our requirements and are certified by the Commonwealth. Both are optical scanning machines which will produce a USB stick with the Cast Vote Records at the end of the election which can be transferred to a central location to be used in the CRC to process election results. There are several additional features for the ImageCast Precinct which are worth mentioning:

- Comes in ADA-compliant configurations, which may obviate the need for separate ADA tabulators.
- May append an image of each ballot cast to the Cast Vote Record for that ballot, which increases transparency and auditability (although this practice may be currently prohibited by the Commonwealth, it may be worth pursuing an exception).
- Diverts ballots with write-ins to a separate bin.
- Is supported by LHS, the regional vendor for Dominion, with whom the Town has an existing relationship.

**Central Results Calculator Options.** There are three options available for CRC software, some of which come with their own hardware.
1. Results Tally and Reporting Software (RTR) by Dominion, which is a software/hardware combination provided by LHS. If we purchase Dominion ImageCast Precinct tabulators, we must also purchase this software as part of the package.

2. Universal RCV Tabulator, which is open source software and would run on an off-the-shelf computer dedicated as the CRC.

3. A custom solution using Excel installed on a/many dedicated off-the-shelf machine(s) and a lot of manual labor.

Note that ES&S does not have software for their tabulators that can calculate the results for multi-winner elections. If we choose to use ES&S tabulators, we must use either the Universal RCV Tabulator or the custom Excel solution. Also worth noting is that if we purchase ImageCast Precinct Tabulators, we must also purchase the RTR software provided by Dominion. As such, we should use this software unless a compelling reason emerges to use another suite.

**Results Tally and Reporting Software (RTR).** The primary benefits of the Results Tally and Reporting Software are:

1. It is developed and supported by Dominion.
2. It is required in order to decrypt the data on the USB sticks from the Precinct Tabulators, so we must purchase it anyway if we are using Dominion Precinct Scanners.

**Universal RCV Tabulator.** The Universal RCV Tabulator is open source software recently developed and certified by Pro V&V, Inc., an EAC-accredited voting systems test lab (US Election Assistance Commission), but has not been certified by any state. It is not, according to the information we have, in use in any town or municipality.

The primary benefits of using this software would be:

1. Because the software is open source it is theoretically more transparent as citizens can download the software, test it out, and review the source code.
2. We can hire an auditor to review the code and ensure that it does exactly what we want it to. There is no black-box issue.
3. While not anticipated, if desired we can hire a development company to change the software to suit our individual needs.
4. There are no licensing fees.

The primary downsides of using this software would be:

1. It is not currently certified by the Commonwealth, which may make getting the Special Act for RCV in Amherst more difficult to pass if the Elections Division comes out against our use of third-party software.
2. If we ever ran into any issues we did not discover during initial testing, we would need to hire developers to fix those problems. Or transition to another product.
3. The town would need to hire someone to thoroughly audit the software and potentially adapt it to our needs if that differed from the software’s stock features.

**Custom Solution using Excel.** Minneapolis currently uses this to calculate the results of its RCV elections. However, it requires an enormous investment of time and workhours in order to calculate the results, and because the process is so labor intensive it is prone to human error in a way that the other systems are not. We would recommend against using this solution, but mention it here as an option.

**Recommendations.** The three most advisable product combinations available are:

1. Dominion ImageCast (Precinct Tabulator) paired with the Dominion Results Tally and Reporting Software (CRC).
2. Dominion ImageCast (Precinct Tabulator) paired with the Universal RCV Tabulator (CRC).
3. ES&S DS200 (Precinct Tabulator) paired with the Universal RCV Tabulator (CRC).

This committee recommends option #1, followed by #2: using Dominion ImageCast Precinct for our precinct level tabulators paired with Dominion Results Tally and Reporting software/hardware combination as our solution.

- We have an existing relationship with LHS, and as both products are from the same company we would expect less potential for errors when transporting data between the machines.
- When using Dominion Tabulator and Results Tally Reporting system, the data exported from the Tabulator will be encrypted so that only the Results Tally Reporting system can read it. When using mixed devices, such as the ImageCast and the open source Universal RCV Tabulator as the CRC, the tabulators would export the precinct data in a more simple, non-encrypted format. While not required, this security boost is a nice plus.
- Any potential software issues will be handled by Dominion.
Section 10. Concluding Remarks

The 2017 Amherst Home Rule Charter requires our Commission to propose a measure to adopt and implement ranked-choice voting in Amherst, starting with the 2021 local elections. This report reviews what we have learned about RCV and makes our recommendations, along with the actions needed to proceed, if the Town Council decides to do so. The most pressing action needed is to get a special act passed by the state legislature, with the assistance of allies such as our local representatives, either to proceed with RCV (using the language in Appendix 1). If Amherst cannot implement RCV for the 2021 elections, e.g., due to delays or because the legislature rejects the Special Act, the Town should have a backup plan for defaulting to running the election according to state law.

The Town will need to work with the Elections Division in the MA Secretary of the Commonwealth’s office to develop an acceptable implementation, including the choice of tabulators, RCV calculation software, recount procedures, and ballot layout. The Elections Division will also need to be aware of our choice of calculation method (WIGM) and how we plan to interpret ballot errors to express the intent of the voter. This effort must occur either before or in conjunction with submitting the special act to the legislature, as satisfying the Elections Division with our implementation will be essential to getting the special act passed.

Another key task for the Town is to determine which voting system to purchase after obtaining quotes and securing the budget. However, in addition to the cost of the new machines and software, there may be additional costs regarding staffing, education, and implementation, which are beyond the scope of this Commission to estimate.

The longest – and most time-consuming phase – will be preparation for the first local election. A considerable amount of time and effort by the Town Council members, Town Clerk’s office, and paid or volunteer ambassadors will need to go into voter education and outreach, so candidates, voters, and poll workers understand the myriad changes required by the new RCV system.

We, the members of the Amherst Ranked-Choice Voting Commission, were honored to be selected. We have worked diligently together to fulfill our commission, and we thank former commission member Carroll (Rob) Robertson for his contributions to our work. We have made recommendations in this report, with explanations justifying those choices, that we believe will lead to a successful implementation of RCV in Amherst.
Respectfully submitted,

Susan Audette (Acting Town Clerk)
John Bryan
Jesse Crafts-Finch (Vice-Chair)
Tanya Leise (Chair)
Ellen Lindsey
Peggy Shannon
Appendix 1. An Act Relative to Ranked Choice Voting in Municipal Elections in the Town of Amherst

SECTION 1. Notwithstanding the provisions of chapters 50 through 54 of the general laws, or any other general or special law to the contrary, the Town of Amherst is hereby authorized to use ranked choice voting in municipal elections only.

SECTION 2. For purposes of this act, the following words and phrases shall have the meanings respectively ascribed to them in this section:

(a) The words, “Continuing candidate” shall mean a candidate who has been neither eliminated nor elected.
(b) The words “Exhausted ballot” shall mean a ballot that is not counted for any continuing candidate because it does not rank any continuing candidates or because the voter’s intent cannot be determined.
(c) The words “Highest continuing ranking” shall mean the highest ranking on a voter's ballot for a continuing candidate.
(d) The word “overvote” shall be the result if a voter ranks more than one (1) candidate at the same ranking.
(e) The words “Ranked-choice voting” shall mean an election method in which voters rank candidates in order of their preference in a contest for an elected office. The calculation of election results occurs in rounds in which votes, or fractions thereof, are distributed to candidates according to the preferences marked on each ballot.
(f) The word “Ranking” shall mean the number assigned by a voter to a candidate to express the voter's preference for that candidate. Ranking number one (1) is the highest ranking.
(g) The words “Repeat candidate ranking” shall mean when a voter ranks the same candidate at multiple rankings for the contest being counted.
(h) The word “Round” shall mean an instance of the sequence of ranked choice voting tabulation steps established in Section 4.
(i) The words “Skipped ranking” shall mean when a voter leaves a ranking blank and ranks a candidate at a subsequent ranking.
(j) The word “Surplus” shall mean the total number of votes cast for an elected candidate in excess of the threshold.

(k) The word “Threshold” shall mean the minimum number of votes required to win a seat.

(l) The words, “Transfer value” shall mean the proportion of a vote that will contribute to the next ranked continuing candidate on a ballot, according to the weighted inclusive Gregory method. Each vote begins with a transfer value of one (1).

SECTION 3. Notwithstanding the provisions of applicable provisions of chapters 53 and 54 of the general laws, Ranked-choice voting ballots for use in the Town of Amherst municipal elections shall be prepared according to a format meeting the below requirements and otherwise consistent with state law.

a) For each contest, the ballot must allow a voter to mark rankings for at least the smaller of (i) the number of seats plus two or (ii) the total number of declared candidates plus write-in candidates.

b) The ballot must indicate the number of seats to be filled for each contest.

c) The ballot must comply with all otherwise applicable provisions of the General Laws and the regulations promulgated thereunder.

SECTION 4. Notwithstanding the provisions of section 2 of chapter 50 of the general laws, for the purposes of this act, votes shall be tallied as follows:

a) Each contest on the ballot will be tabulated in rounds in which votes, or fractions thereof, are distributed to candidates according to the preferences marked on each ballot. A ranked choice voting procedure will be employed in which a voter's lower ranked choice may not impact the likelihood of a higher ranked choice being elected and in which the order of the ballots may not affect the outcome. In each contest, no voter’s ballot will have a total vote value greater than one (1).

b) The Town Clerk, subject to review by the Board of Registrars, shall determine the number of valid ballots thereafter used to calculate the threshold at each round.

i. If a candidate’s total vote count equals or surpasses the threshold, that candidate must be declared elected.
ii. That candidate’s surplus must then be distributed according to the highest continuing ranking on each ballot that contributed to that candidate’s vote count, according to each ballot’s transfer value.

iii. If no continuing candidate’s total vote count equals or surpasses the threshold after the first distribution, then the continuing candidate with the lowest vote count must be eliminated, and the eliminated candidate’s votes must be transferred according to the highest continuing ranking on the eliminated candidate’s ballots. Votes from exhausted ballots will not be transferred.

iv. The process set forth in sections 3(b)(i)-(iii) shall be repeated until the number of elected candidates equals the number of seats to be filled or the number of continuing candidates equals the number of seats yet to be filled. In the latter case, the remaining continuing candidates must be declared elected, at which point the election for that contest will be complete.

c) The Town Clerk, subject to review by the Board of Registrars will establish a method of tiebreaking that will be used when ties occur in this procedure. The results of any such tiebreaking events must be recorded and reused in the event of a recount. The method for tiebreaking may be amended from time to time, but shall not be amended during the course of an election, including any and all recounts.

d) When a skipped ranking or repeat candidate ranking is encountered on a ballot, that vote shall count towards the highest continuing ranking. In the case of an overvote involving two or more continuing candidates, the overvote candidates and all subsequently ranked candidates will be disregarded. If any vote cannot be advanced because no further continuing candidates are ranked on that ballot, that ballot shall be declared exhausted for that contest.

SECTION 5: If any part of this Act is declared unconstitutional by a court of competent jurisdiction, the remaining parts shall survive in full force and effect. If a conflict arises between this Act and any other provision of law, the policies and purposes of this Act shall govern.

SECTION 6: This Act shall take effect immediately upon its approval; provided, however, that it shall be applicable only to municipal elections occurring on or after _____ day of ____________ 20____.
### 2021 TOWN ELECTION INFORMATION AND CALENDAR

The city or town clerk shall not furnish blank forms for nomination of candidates for city or town office to any person other than a candidate seeking such nominations or a person presenting the signed authorization of a candidate to secure said forms on his behalf. (53:17)

No nomination paper shall be received or be valid unless the written acceptance of the candidate thereby nominated shall be filed therewith. (53:9)

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuesday, June 1, 2021</td>
<td>Nomination papers* available in the office of the Town Clerk</td>
</tr>
<tr>
<td>Tuesday, July 6, 2021</td>
<td>Last day for Board of Registrars to certify signatures on supplementary petitions for initiative measures in order for Council to include initiative measure ballot questions on Town Election ballot [Charter Sec. 8.3(d)]</td>
</tr>
<tr>
<td>Tuesday, September 14, 2021</td>
<td>5:00 PM</td>
</tr>
<tr>
<td>Tuesday, September 28, 2021</td>
<td>4:30 PM</td>
</tr>
<tr>
<td>Thursday, September 30, 2021</td>
<td>5:00 PM</td>
</tr>
<tr>
<td>Monday, October 4, 2021</td>
<td>Town Clerk draws names for placement on ballot for all offices [Charter Sec. 7.1]</td>
</tr>
<tr>
<td>Wednesday, October 13, 2021</td>
<td>8:00 PM</td>
</tr>
<tr>
<td>Monday, October 25, 2021</td>
<td>4:30 PM</td>
</tr>
<tr>
<td>Tuesday, October 26, 2021</td>
<td>4:30 PM</td>
</tr>
<tr>
<td>Tuesday, October 26, 2021</td>
<td>4:30 PM</td>
</tr>
<tr>
<td>Tuesday, November 2, 2021</td>
<td>7 AM - 8 PM</td>
</tr>
<tr>
<td>Thursday, January 21, 2022</td>
<td>4:30 PM</td>
</tr>
</tbody>
</table>

### OFFICERS TO BE ELECTED

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<th>Position</th>
<th>Term Length</th>
<th>Number</th>
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<tbody>
<tr>
<td>Town Councilor</td>
<td>Thirteen for two years</td>
<td>3 At-Large**, 10 District*</td>
</tr>
<tr>
<td>Jones Library Trustee**</td>
<td>Six for two years</td>
<td></td>
</tr>
<tr>
<td>School Committee**</td>
<td>Five for two years</td>
<td></td>
</tr>
<tr>
<td>Oliver Smith Will Elector**</td>
<td>One for two years</td>
<td></td>
</tr>
<tr>
<td>Housing Authority**</td>
<td>Three for two years</td>
<td></td>
</tr>
</tbody>
</table>

* ** NOMINATION PAPERS - NUMBER OF SIGNATURES REQUIRED

<table>
<thead>
<tr>
<th>Position</th>
<th>Signature Requirement</th>
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</thead>
<tbody>
<tr>
<td>District Councilor</td>
<td>Minimum of 25 voters of the town</td>
</tr>
<tr>
<td>Town-wide Office**</td>
<td>Minimum of 50 voters of the town</td>
</tr>
</tbody>
</table>
Appendix 3: Sample Amherst RCV Ballot

We provide here a sample ranked choice ballot to give a sense of what the layout might look like for an Amherst election. Note that this is not an official ballot and that the actual ballot layout and details will differ from this example.
Appendix 4: Other Places Using RCV

Here we highlight some of the other towns, cities, states, and countries that have adopted, plan to adopt, or have dropped RCV for their elections. For a more complete listing that is regularly updated, see https://www.fairvote.org/where_is_ranked_choice_voting_used.

Who is currently using Ranked Choice Voting? (as of November 2020)

- Single winner elections: San Francisco, Berkeley, San Leandro, and Oakland (CA), Basalt, Carbondale, and Telluride (CO), Portland (ME), the state of Maine, Takoma Park (MD), La Cruces and Santa Fe (NM)
- 2020 Presidential Nominations (primaries and caucuses): Alaska, Hawaii, Kansas, Nebraska, Wyoming
- Multi-winner: Cambridge (MA), Eastpointe (MI), Minneapolis, St. Paul, and St. Louis Park (MN)
- Military and overseas voters: Alabama, Arkansas, Louisiana, Mississippi, and South Carolina
- Outside the US: Australia, Ireland, New Zealand, Malta, Northern Ireland, and Scotland
Who has adopted RCV but not yet implemented it?

- Benton County (OR) may use as soon as November 2020
- Easthampton (MA) and New York City may use in 2021
- Palm Desert (CA) may use in November 2022
- Alaska recently passed a ballot initiative to use RCV in statewide elections
- Eureka, CA also recently approved RCV to elect the mayor and town council

Where has RCV recently been challenged or rejected?

- Massachusetts – Ballot Measure 2 failed in the November 2020 state election by 55% to 45%. The measure would have required RCV for certain statewide primaries and general elections and may have failed at least partly due to coronavirus-related restrictions in campaign and voter education efforts.

- Burlington, VT – After using the system for five years, Burlington voters repealed ranked-choice voting in 2010 after an upset in the final tabulation round for mayor led to an unexpected winner. Burlington residents attempted to reinstate RCV in late 2019, but in August 2020 the Mayor vetoed a measure to put RCV on the November 2020 ballot, objecting to the cost of adding the referendum to the general election ballot and the fact that RCV “will consume community attention and resources at a moment in which those finite resources are urgently needed elsewhere.”

  - https://thefulcrum.us/ranked-choice-voting-2646939331

- Maine – The use of RCV to elect positions such as U.S. House representative and U.S. president has been unsuccessfully challenged multiple times by the GOP in Maine (the latest failed challenge was in August 2020).

  - https://apnews.com/article/election-2020-referendums-elections-maine-courts-b5ddd0854037e9687e952cd79e1526df

- California – A bill to use RCV was passed in the state Senate and Assembly but vetoed by Gov. Newsom, who claims “Ranked choice is an experiment… I am concerned that it has often led to voter confusion and that the promise that ranked-choice voting leads to greater democracy is not necessarily fulfilled.”

Appendix 5. RCV Election Resources from Minneapolis

In 2006, Minneapolis voters approved use of RCV to elect the Mayor, City Council, and members of the Park and Recreation Board, Library Board, and Board of Estimate and Taxation without a separate primary election, starting in 2009. Use of RCV in these elections has survived an immediate challenge in court and subsequent challenges. Minneapolis uses ES&S DS200s for their ranked choice voting elections, using the following steps:

1) DS200 machines scan in the ranked choice ballots to the DS200
2) The DS200 tabulates votes cast for each race and ranking.
3) At the close of voting, the election judge:
   a. Prints out at least three physical copies of the results tape (for public display, for storage, and for reporting to the central counting location)
   b. Using a secure modem or direct download to a secure server, sends the Cast Vote Record directly from each DS200 to a central tabulation location.
4) Once the cast vote records from each precinct are all received at the central tabulation location, each DS200's cast vote record is merged into one complete cast vote record containing data from every ballot cast in the election.
5) The complete cast vote record is exported from the election software, and the RCV election results are calculated using an Excel-based method developed by Minneapolis election officials.

Minneapolis has developed a website with multiple RCV resources:

- https://vote.minneapolismn.gov/ranked-choice-voting/

Minneapolis’s voter outreach effort has included accessible and informative videos on RCV:

- Two-minute video with an overview of how RCV works (https://youtu.be/53z9feU1qdg)
- Visually appealing demonstration of multi-winner RCV (https://youtu.be/lNxwMdl80Ww)

Providing an online FAQ to explain how RCV will be used in local elections may be a helpful way to answer voters’ questions, as illustrated on Minneapolis’s RCV website:

- https://vote.minneapolismn.gov/ranked-choice-voting/details/

For an example of how to publish detailed RCV election results, see the following example from the 2017 Minneapolis mayoral election

Minneapolis has posted their election worker training materials:

- https://vote.minneapolismn.gov/election-workers/

Minneapolis has also posted a detailed voter outreach plan:

- https://www.electioncenter.org/publications/2014PPP/Minneapolis,_MN_-_Developing_A_Voter_Outreach.pdf (2014), which covers the following:
  o Voter Ambassador Program – enlisting both resident volunteers and partner organizations to receive training and resources to talk with friends, neighbors, and spheres of influence.
  o Educational sessions – a small number were held at City Hall and public libraries, most occurred with organizational partners at their sites to share information with clients or employees.
  o Social media – Elections & Voter Services established its own Twitter and Facebook accounts, as well as utilizing the City’s official social media channels to share education materials and messages, and promote further sharing by residents with their own networks.
  o Community events and festivals – tabling and canvassing with the help of both ambassadors and organizational partners with more volunteers like FairVote Minnesota.
  o Mock elections – held in four high schools in the four geographic quadrants of the city and at City Hall to demonstrate new equipment and share information about RCV.
  o Vote Minneapolis Activity books - distributed in public libraries and elementary schools.
  o High school classroom visits – presentations sharing how RCV works, the role of City government, and opportunities for students to serve as election judges.
  o College student engagement – student interns conducted focused outreach on university campuses through student groups.
  o Advertising – utilized three major venues at no cost: cards placed on the interior of public buses with routes through the city; messages on digital billboards during donated time; 30-second public service announcement produced to air during donated airtime on the cable system.
  o Voter information guide – mailing to every household in the city, including a sample ballot.
 Appendix 6. RCV Election Resources from San Francisco

San Francisco held its first RCV election in 2004. Their original vendor was Sequoia Voting Systems, which was acquired by Dominion in 2010. As of the November 5, 2019 election, San Francisco is switching to Dominion’s Democracy Suite. (See https://sfelections.sfgov.org/article/department-elections-announces-san-francisco-voters-will-begin-using-new-voting-system.)

Reasons given for switching to the new system include:

- **Intuitive Ballot Marking**: Voters will continue to use paper ballots to cast their votes. However, voters will fill in ovals next to their selections, instead of connecting arrows.

- **Increased Number of Rankings in Ranked-Choice Voting Contests**: Using an efficient grid layout for ranked-choice voting contests, the new system allows voters to rank up to a maximum of 10 candidates, instead of the limit of three candidates that the previous voting system allowed.

- **Expanded Accessibility**: The new accessible ballot-marking device offers better audio and touchscreen interfaces, and is compatible with a number of assistive devices.

- **Improved Transparency**: Digital images of voted ballots and records of how the equipment interpreted vote-marks will be posted online. Members of the public can download and tally these images to independently verify election results.

- **Enhanced Security**: No part of the new voting system connects to the internet at any time or electronically receives or transmits election data through any type of external communication network.

The San Francisco Department of Elections has a website (https://sfelections.sfgov.org/learn-about-voting-system) introducing voters to the new ballot format and provides an animation of marking a ranked-choice voting ballot.

To educate San Francisco voters about the new voting system, the Department of Elections rolled out a robust outreach program. The program includes various strategies, including newspaper notices in multiple languages, posters on Muni and BART vehicles, PSAs for television and radio, household mailers, posts on social media, and presentations throughout the City. These and other planned outreach efforts are discussed in their draft outreach plan (https://sfelections.sfgov.org/sites/default/files/Documents/DRAFT_2019_OR_Plan.pdf).

Appendix 7. Examples of RCV Voter Education and Outreach Resources

Minneapolis and Maine have developed websites with multiple RCV resources:

- [https://vote.minneapolismn.gov/ranked-choice-voting/](https://vote.minneapolismn.gov/ranked-choice-voting/)

Minneapolis’s voter outreach effort has included accessible and informative videos on RCV:


Providing an online FAQ to explain how RCV will be used in local elections may be a helpful way to answer voters’ questions, as illustrated on Minneapolis’s RCV website:

- [https://vote.minneapolismn.gov/ranked-choice-voting/details/](https://vote.minneapolismn.gov/ranked-choice-voting/details/)

Other resources are available on websites of organizations advocating for RCV:

- Ranked Choice Voting Resource Center: www.rankedchoicevoting.org
- Voter Choice Mass: www.voterchoicema.org
- FairVote: www.fairvote.org
Appendix 8: Voting System Hardware and Software Options

Dominion Voting

- Website: www.dominionvoting.com
- ImageCast Precinct product page: https://www.dominionvoting.com/imagecast-precinct/
- Democracy Suite Election Management System (which contains the Results Tally and Reporting Software): https://www.dominionvoting.com/democracy-suite-ems/

Election Systems & Software (ES&S)

- Website: www.essvote.com

Universal RCV Tabulator

- Code repository: https://github.com/BrightSpots/rcv/releases/
- Description: https://www.rankedchoicevoting.org/universal_rcv_tabulator
Appendix 9. Glossary

For more complete glossaries of RCV and other election-related terms, see www.fairvote.org/glossary and https://www.rankedchoicevoting.org/faq.

CAST VOTE RECORD: a spreadsheet or other data file generated by a precinct tabulator (voting machine) that contains the information on how each ballot was marked.

CENTRAL RESULTS CALCULATOR: software that runs on a standalone computer which compiles the Cast Vote Records from all of the tabulators and calculates the election results.

EXHAUSTED BALLOT: a ballot that is not counted for any continuing candidate because it does not rank any continuing candidates or because the voter’s intent cannot be determined.

MULTI-WINNER RANKED CHOICE VOTING: a proportional voting system used in contests for multiple seats (such as a multi-member district or a school committee) in which voters rank candidates in order of preference.

OVERVOTE: occurs when a voter ranks more than one (1) candidate at the same ranking in a contest.

PLURALITY BLOCK VOTING: an election method used in multi-winner contests in which voters can vote for, or approve of, as many candidates as they wish, up to the number of available seats. Each candidate approved receives one vote and the candidates with the most votes win. The winners need not garner a majority of the votes.

PLURALITY VOTING: an election method used in single-winner contests in which voters can only choose one candidate to mark on their ballot. The candidate with the most votes wins, without necessarily receiving a majority of votes.

RANKED CHOICE VOTING: an election method in which voters rank candidates in order of their preference in a contest for an elected office. The calculation of election results occurs in rounds in which votes, or fractions thereof, are distributed to candidates according to the preferences marked on each ballot. Ranked choice voting may be applied to both single- and multi-winner contests. The terms instant runoff voting, single transferable vote, preference voting, and the alternative vote all refer to ranked choice voting. The term instant runoff voting (IRV) only refers to a single-winner contest, e.g., for mayor or governor. The term single transferable vote (STV) usually refers to a multi-winner contest, e.g., for a city council or legislature.
**RANKING**: the number assigned by a voter to a candidate to express the voter's preference for that candidate. Ranking number one (1) is the highest ranking. Any rankings below the number of candidates for office will be disregarded (i.e. “7” when there are 6 candidates for office).

**REPEAT CANDIDATE RANKING**: occurs when a voter ranks the same candidate at multiple rankings for the contest being counted.

**SINGLE-WINNER RANKED CHOICE VOTING**: a voting system used in elections with a single winner (such as mayor or governor) in which voters rank candidates in order of preference. If more than half of the voters ranks a particular candidate in first place, that candidate wins the election. If no candidate has more than half of the first-place votes, then the candidate with the fewest first place votes is eliminated and votes for that eliminated candidate are redistributed to the next ranked candidate marked on each ballot. This process continues until a winner is declared.

**SKIPPED RANKING**: occurs when a voter leaves a ranking blank and ranks a candidate at a subsequent ranking.

**SURPLUS**: the total number of votes cast for an elected candidate in excess of the threshold.

**THRESHOLD**: the minimum number of votes required to win a seat.

**TRANSFER VALUE**: the proportion of a vote that will contribute to the next ranked continuing candidate on that ballot. Each vote begins with a transfer value of one (1).

**UNDERVOTE**: occurs when a voter does not mark any candidates for a contest (leaves that contest blank on the ballot).

**WASTED VOTES**: votes that don’t count toward electing a winning candidate. These votes include ballots cast for a losing candidate, as well as excess votes for a winning candidate beyond what was needed to win a seat.
Appendix 10. Example of a WIGM RCV Calculation

To demonstrate how the results of an RCV election might be computed, the following example illustrates some technical details of the weighted inclusive Gregory method (WIGM) and highlights what is involved in fully specifying the RCV method used to determine the results of an election. Note that the example below makes certain choices in the details of the algorithm, and the Town of Amherst may make somewhat different choices in its implementation.

The purpose of WIGM is to appropriately transfer surplus votes in multi-winner elections, thereby reducing “wasted” votes and aiming for a more representative outcome. This method has been used in Minneapolis local elections since 2009 and in Scottish Parliament elections since 2007 (see James Gilmour’s 2007 article for further details, and https://blog.opavote.com/2016/11/plain-english-explanation-of-scottish.html for an accessible description).

For a possible hand count protocol, see Gilmour’s detailed rules for Scottish Parliament, and see http://www.cix.co.uk/~rosenstiel/stvrules/model.htm for a worked example. The information below is based on https://prfound.org/resources/reference/.

Note on Arithmetic Precision

For WIGM, the arithmetic precision chosen will determine how small a difference in vote count between two candidates can be resolved; any smaller differences will be treated as ties. For hand-counting WIGM RCV with a calculator, it’s desirable to be able to see the full precision of a product of two values, in order to perform proper rounding. For most hand calculators, four digits of precision is a practical upper limit, so that eight digits of precision in the product can be seen. The reference WIGM rule specifies four digits of precision, as does Minneapolis MN, while Scotland specifies five digits.

For reproducibility of results, a rule for consistent rounding of all numbers, including intermediate calculations, should be set a priori. In calculating the threshold, the options are whether to round the intermediate product (ballot weight * surplus) before dividing by the candidate’s total vote, and if so how (up or down), and whether to round the result of the final division up or down. The usual choices are to round down in both cases. Retaining the full intermediate precision is an option, but notice that if a count is made by hand, many calculators will not provide enough precision for this calculation, so if the ability to count by hand is desirable, the intermediate product should be rounded down.

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4 www.votingmatters.org.uk/RES/gilmour7.pdf
Basic Version of WIGM using 4-Digit Precision and Batch Elimination

A. Initialize Election

1. Set the threshold (minimum number of votes required to win a seat) to the total number of valid ballots, divided by one more than the number of seats to be filled, then rounding this fraction down to the nearest integer and adding one.
2. Set each candidate who is not withdrawn to hopeful.
3. Test whether the count complete.
4. Set each ballot’s weight to one, and assign it to its top-ranked hopeful candidate.
5. Set the vote for each candidate to the total number of ballots assigned to that candidate.

B. General Procedures

1. Break ties. Ties arise in choosing the candidate for surplus transfer and in choosing the candidate for elimination. In each case, choose the tied candidate who is earliest in a predetermined random tiebreaking order.
2. Transfer ballots. Reassign each ballot to be transferred to its highest-ranking hopeful candidate and add the current weight of the ballot to the vote of that candidate. If the ballot ranks no such candidate, or has a weight of zero, it is exhausted and no longer participates in the count.
3. Test whether all seats filled. If the number of elected plus pending candidates is equal to the number of seats to be filled, or the number of elected plus pending plus hopeful candidates is equal to or less than the number of seats to be filled, the count is complete.
4. Arithmetic. Truncate, with no rounding, the result of each multiplication or division to four decimal places.

C. Rules Governing Each Round

1. Elect winners. Set each hopeful candidate whose vote is greater than or equal to the threshold to pending (elected with surplus-transfer pending). Set the surplus of each pending candidate to that candidate’s vote minus the threshold. Test whether done filling seats.
2. Defeat sure losers (only in 1st round). Find the largest set of hopeful candidates that meets all of the following conditions.
   a. The number of hopeful candidates not in the set is greater than or equal to the number seats to be filled minus pending and elected candidates.
   b. For each candidate in the set, each hopeful candidate with the same vote or lower is also in the set.
c. The sum of the votes of the candidates in the set plus the sum of all the current surpluses is less than the lowest vote of the hopeful candidates not in the set.

If the resulting set is not empty, eliminate each candidate in the set, transfer each ballot assigned to an eliminated candidate, and start a new round.

3. **Transfer high surplus.** Select the pending candidate, if any, with the largest surplus (possibly zero), breaking ties per procedure D.1. For each ballot assigned to that candidate, set its new weight to the ballot’s current weight multiplied by the candidate’s surplus, then divided by the candidate’s total vote. Transfer the ballot. If a surplus (possibly zero) is transferred, start a new round.

4. **Defeat lowest candidate (if no candidate meets threshold).** Defeat the hopeful candidate with the lowest vote, breaking ties as needed. Test whether all seats are now filled. Transfer each ballot assigned to the eliminated candidate to the next ranked candidate. Start a new round.

D. **Finish Count of Winners**

Set all pending candidates to elected. If all seats are filled, defeat all hopeful candidates; otherwise elect all hopeful candidates. Count is complete.

**Example with 3 Seats to Fill (adapted from Gilmour’s 2007 article)**

*Round 1:* winning threshold is \(\left\lfloor \frac{2397}{3+1} \right\rfloor + 1 = 599 + 1 = 600\)

<table>
<thead>
<tr>
<th>Candidate</th>
<th>1st place votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams</td>
<td>550</td>
</tr>
<tr>
<td>Baker</td>
<td>377</td>
</tr>
<tr>
<td>Campbell</td>
<td>972</td>
</tr>
<tr>
<td>Gray</td>
<td>167</td>
</tr>
<tr>
<td>Miller</td>
<td>331</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2397</strong></td>
</tr>
</tbody>
</table>

Campbell is elected with 972 votes, and has 372 surplus votes, all still at full value of 1. Transfer value will be \(\frac{372 \times 1}{972} = 0.3827\). Suppose next ranked is Adams on 357 of these ballots, Baker on 223, Gray on 83, and Miller on 252. No further preferences are given on 57 (exhausted ballots).
Round 2

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Votes worth 1</th>
<th>Votes worth 0.3827</th>
<th>Total votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams</td>
<td>550</td>
<td>357</td>
<td>686.6239</td>
</tr>
<tr>
<td>Baker</td>
<td>377</td>
<td>223</td>
<td>462.3421</td>
</tr>
<tr>
<td>Gray</td>
<td>167</td>
<td>83</td>
<td>198.7641</td>
</tr>
<tr>
<td>Miller</td>
<td>331</td>
<td>252</td>
<td>427.4404</td>
</tr>
<tr>
<td>Non-transferable</td>
<td>57</td>
<td>21.8295</td>
<td></td>
</tr>
</tbody>
</table>

Adams is elected with 86.6239 surplus votes, 550 of which currently have value 1 and 357 of which have value 0.3827. The former will be transferred with value $\frac{86.6239 \times 1}{686.6239} = 0.1262$ and the latter with value $\frac{86.6239 \times 0.3827}{686.6239} = 0.0483$. See table below for who these are transferred to.

Round 3

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Votes worth 1</th>
<th>Votes worth 0.3827</th>
<th>Votes worth 0.1263</th>
<th>Votes worth 0.0483</th>
<th>Total votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baker</td>
<td>377</td>
<td>223</td>
<td>24</td>
<td>12</td>
<td>465.9529</td>
</tr>
<tr>
<td>Gray</td>
<td>167</td>
<td>83</td>
<td>407</td>
<td>221</td>
<td>260.8425</td>
</tr>
<tr>
<td>Miller</td>
<td>331</td>
<td>252</td>
<td>98</td>
<td>119</td>
<td>445.5655</td>
</tr>
<tr>
<td>Non-transferable</td>
<td>57</td>
<td>21</td>
<td>5</td>
<td>24.6391</td>
<td></td>
</tr>
</tbody>
</table>

No remaining hopeful meets the threshold for winning, so the lowest is eliminated (Gray), transferring those ballots at their current indicated worth (weight).

Round 4

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Votes worth 1</th>
<th>Votes worth 0.3827</th>
<th>Votes worth 0.1263</th>
<th>Votes worth 0.0483</th>
<th>Total votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baker</td>
<td>377+61</td>
<td>223+38</td>
<td>24+130</td>
<td>12+160</td>
<td>565.6425</td>
</tr>
<tr>
<td>Miller</td>
<td>331+106</td>
<td>252+44</td>
<td>98+271</td>
<td>119+40</td>
<td>604.5636</td>
</tr>
<tr>
<td>Non-transferable</td>
<td>57+1</td>
<td>21+6</td>
<td>5+21</td>
<td>26.7939</td>
<td></td>
</tr>
</tbody>
</table>

Miller now passes the winning threshold and is elected.

Final result: The 3 seats are filled by Adams, Campbell, and Miller.