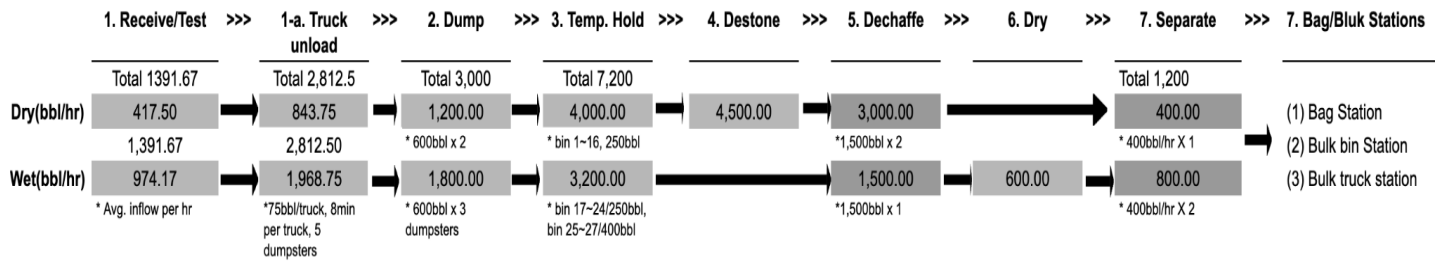
1. *How does the current process at receiving plant 1 work? Draw a process flow diagram.*

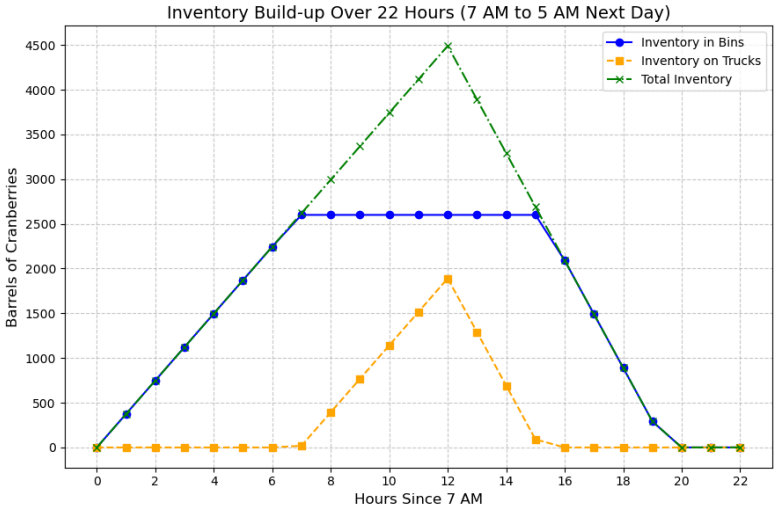
1. Process Map



2. *What is the capacity rate of the plant? What is the throughput rate? Please state any assumptions you are making about how wet and dry flow are allocated to the separator.*

- **Capacity Rate:** The plant's capacity rate is 1,200 bbl/hr, determined by the combined capacity of the Jumbo Separators, which process up to 1,200 bbl/hr (400 bbl/hr per unit × 3 units).
- **Throughput Rate:** The actual throughput rate is **1,018 bbl/hr**, calculated by combining the throughput of wet and dry berries:
  - **Wet Berries**: With an input rate of **974 bbl/hr** (70% of 1,392 bbl/hr), the throughput is constrained by the **dryer's bottleneck** at **600 bbl/hr**.
  - **Dry Berries**: The input rate is **418 bbl/hr** (30% of 1,392 bbl/hr). As there are no bottlenecks in the process for dry berries, the throughput remains at **418 bbl/hr**.
- **Key Assumption**: After drying, wet berries are combined with dry berries and fed into the **Jumbo Separators** for further processing.

3. *Assuming that processing starts at 7 am on a "busy" day, present the situation during such a day, by constructing an inventory build-up diagram. The inventory build-up diagram should have time on the horizontal axis and inventory on the vertical one. It will help if the inventory build-up diagram separately shows the build-up of inventory in the holding bins, and the build-up of inventory in the trucks (i.e., trucks that are unable to dump their contents because the holding bins are full.)*



4. *Clearly identify and discuss the deficiencies of the current system.*

- **Dryer Bottleneck**: With wet berries comprising 70% of the volume, the dryers (3 units at 200 bbl/hr each, total 600 bbl/hr) have become the primary bottleneck, limiting plant throughput despite the separators' capacity of 1,200 bbl/hr.
- **Truck Unloading Delays**: When holding bins reach capacity, trucks face long wait times, increasing grower transportation costs and causing frustration.
- **Limited Holding Bin Allocation**: Wet berries are restricted to bins #17–24 (250 bbl each) and #25–27 (400 bbl each), totaling 3,200 bbl. As wet berry volumes have surged (25,000 bbl in 1993 → 350,000 bbl in 1995), bins fill quickly, forcing costly truck idling ($100/hr for leased trucks). Dry bins cannot be used for wet berries without $10,000 modifications per bin.
- **High Overtime Costs**: To prevent wet berries from remaining overnight, the plant often operates beyond the standard 7 AM–11 PM schedule, incurring significant overtime labor costs. Seasonal workers earning 1.5× pay exacerbate these costs.
- **Inaccurate Grading**: Manual berry grading results in nearly half of #3-rated berries being misclassified, leading to overpayment of $1.50/bbl premiums.
- **System Inflexibility**: The current scheduling system struggles to adapt to fluctuations in input rates, leading to inefficiencies and reduced responsiveness.

5. *Evaluate the costs and benefits of three capital investments: the fifth Kiwanee dumper purchased last year, Walliston's proposal for two new dryers, and the light meter system for color grading.*
   - **5th Kiwanee Dumper**:
     - Increased unloading capacity to **3,000 bbl/hr**, but at $200,000, it is underutilized due to the drying bottleneck. Additional investment in dryers is necessary to fully leverage this capacity.
   - **Additional Dryers**:
     - **Cost**: $120,000 + $20,000 annual maintenance.
     - **Impact**: Adding two dryers increases wet throughput to **1,000 bbl/hr**, reducing truck wait times ($10,667/day savings) and overtime costs ($384/day savings for 4 hours/day of overtime)
   - **Truck Wait Time Reduction**:
     - **Cost Savings**: Eliminating delays saves **$6,000/day** for a 12-hour shift ($500/hour).
   - **Light Meter System**:
     - **Cost**: $40,000 + $15,600/year for a skilled operator.
     - **Impact**: Prevents misclassification of berries as #3, reducing overpayments. In 1995, misclassifications cost $337,500. After operator wages, potential savings exceed **$200,000/year**.

6. *What other recommendations, both short-term and long-term, would you make to Mr. Schaeffer? Clearly state the benefits of each recommendation.*
   - **Short-Term Solution: Conversion of Dry Bins for Wet Berry Storage:**
     - **Proposal:** Invest $10,000 per bin to convert 2–4 dry bins to accommodate wet berries. This would expand short-term wet storage capacity, alleviating the bottleneck caused by the increased volume of water-harvested berries (expected to rise to 70% of total berries in 1996 from 58% in 1995).
     - **Benefits:**
       - This approach is significantly more cost-effective compared to installing new dryers (costing $60,000 per unit).
       - Reduces truck wait times and associated costs (estimated $100/hour for leased trucks and drivers).
       - Temporarily mitigates the storage issue without requiring extensive structural changes.
     - **Context:** With wet berries' growing share, holding bins for wet berries (currently 3,200 bbl capacity) often reach capacity quickly, causing trucks to queue for extended periods. Converting dry bins addresses this gap.

   - **Long-Term Solution: Separator Line Expansion:**
     - **Proposal:** Plan for an additional separator line (estimated cost: $200,000), or upgrade the existing separators to increase processing capacity.
     - **Benefits:**
       - Future-proofs the plant's processing capability, supporting both wet and dry berries without delays.
       - Avoids creating a new bottleneck downstream of the dryers, ensuring a balanced system.
     - **Context:**
       - Current separators have a combined capacity of 1,200 bbl/hr (3 units at 400 bbl/hr each). If drying capacity is expanded (e.g., by adding dryers), throughput could reach or exceed this limit, moving the bottleneck to the separators.
       - Upgrading separators ensures that the entire processing line can handle increased capacity, maintaining efficiency across operations.

Appendix:Code for Q3

```
import numpy as np
import matplotlib.pyplot as plt

# ------------------
# PARAMETERS
# ------------------
hours = 22
arrival_hours = 12
arrival_bbls = 16700
wet_percentage = 0.7
process_rate = 600       # bbl/hr (bottleneck of wet berries)
bin_capacity = 3200      # total bbl capacity in wet bins

def arrival_rate(t):
    """
    Piecewise arrival rate:
    - Constant delivery rate during the arrival hour window (7 AM - 7 PM)
    - No delivery (0 bbl/hr) for t in [12, 22) (7 PM - 5 AM next day)
    """
    return arrival_bbls * wet_percentage / arrival_hours if 0 <= t < arrival_hours else 0

# ------------------
# INITIALIZATION
# ------------------
# Arrays to track inventory and queue
bin_inv = np.zeros(hours + 1)
truck_queue = np.zeros(hours + 1)

# ------------------
# SIMULATION
# ------------------
for t in range(1, hours + 1):
    # (A) Arrivals add to the truck queue
    arrivals_this_hour = arrival_rate(t - 1)
    truck_queue[t] = truck_queue[t - 1] + arrivals_this_hour

    # (B) Unload from trucks into bins if space allows
    space_in_bins = bin_capacity - bin_inv[t - 1]
    if truck_queue[t] <= space_in_bins:
        bin_inv[t] = bin_inv[t - 1] + truck_queue[t]
        truck_queue[t] = 0
    else:
        bin_inv[t] = bin_capacity
        truck_queue[t] -= space_in_bins

    # (C) Process from bins up to the process rate
    if bin_inv[t] >= process_rate:
```

```
        bin_inv[t] -= process_rate
    else:
        leftover_capacity = process_rate - bin_inv[t]
        bin_inv[t] = 0

        # (C.1) Utilize leftover capacity to process directly from trucks
        if truck_queue[t] > 0:
            truck_queue[t] = max(0, truck_queue[t] - leftover_capacity)

# ------------------
# VISUALIZATION
# ------------------
time_points = np.arange(hours + 1)  # Discrete hours from 0 to 22
plt.figure(figsize=(9, 6))

# Plot inventory in bins
plt.plot(time_points, bin_inv, label="Inventory in Bins", marker='o', linestyle='-', linewidth=1.5,
color='blue')
# Plot truck queue
plt.plot(time_points, truck_queue, label="Inventory on Trucks", marker='s', linestyle='--',
linewidth=1.5, color='orange')
# Plot total inventory
plt.plot(time_points, bin_inv + truck_queue, label="Total Inventory", marker='x', linestyle='-.',
linewidth=1.5, color='green')

# Add title and labels
plt.title("Inventory Build-up Over 22 Hours (7 AM to 5 AM Next Day)", fontsize=14)
plt.xlabel("Hours Since 7 AM", fontsize=12)
plt.ylabel("Barrels of Cranberries", fontsize=12)

# Customize ticks
plt.xticks(range(0, hours + 1, 2), fontsize=10)
plt.yticks(range(0, 5000, 500), fontsize=10)

# Add legend
plt.legend(loc="upper right", fontsize=10)

# Add grid for clarity
plt.grid(True, linestyle='--', alpha=0.7)

# Tighten layout and show the plot
plt.tight_layout()
plt.show()
```