1 Conceptual Design Report

1.1 Background – Problem Description

Kemito Pipfruit are a logistics company. Their operations are the transhipment of produce (avocados and apples) from suppliers to packhouses and packhouses to markets. Our company delivered a packing machine investment plan to minimise the acquisition and installation machine cost whilst able to meet historical demand.

Kemito Pipfruit want to build a model to simulate the transhipment of both their avocado and apple supply chains. The purpose of the simulation is to investigate the role uncertainty plays in their operations and the effect on their machine investment plan. In particular, both the uncertainty in transhipment processes and supply chain interactions are of interest.

The company's transhipment operations have temporal, capacity and loading constraints. Trucks, with a capacity of 100 units of produce, arrive at the suppliers at 7am to begin loading fruit. After loading is complete, the fruit is transported to the relevant packhouses for unloading before packing can begin. After packing, the fruit is loaded into another truck, shipped to the relevant market for unloading. Kemito Pipfruit aim to have all fruit delivered to the relevant market by 5pm. Loading bays at each destination (supplier, packhouse and market) have the capacity to load or unload one truck at a time.

Kemito Pipfruit wish to investigate the submitted packing machine investment plan. The company seeks an assessment on how suitable the plan is. The assessment is in terms of the plan's cost and the ability to deliver fruit on time under supply chain uncertainties. The existing plan was built on the following considerations; transportation and machine costs, averaging processing rates and the historical demands per period.

1.2 Objectives of the study;

The Objective of the study is to validate the packing machine investment plan. Kemito Pipfruit are interested in the quantity and size of packing machines at each location. The setup is to ensure all produce travels from the suppliers to the markets via the packhouses for the week, to meet 100% of demand 95% of the time. The setup is to ensure **95%** of trucks wait no more than **10 minutes** in the supplier, market and packhouse loading bays for loading/unloading, **95% of produce** wait no more than **30 minutes** to be packed, and **95% of produce** waits no more than **30 minutes** to be loaded. Due to loading bay constraints, only one truck may be loaded/unloaded each time. Each truck can transport up to 100 units at a time. Ideally, no produce is to be unloaded at a market past 5pm or loaded at a supplier before 7am and after 5pm. The number and size of packing machines at each location are fixed to our investment plan first but are not constrained, therefore will change in subsequent iterations. Produce is shipped daily. It is required to meet weekly demand.

1.3 Expected benefits;

The expected benefits are a virtual environment for evaluating the subsequent factors:

- Supplier, packhouse and market truck loading/unloading times.
- Produce packing and distribution waiting times (avocados/apples).
- The total time trucks spend transporting produce from supplier to packhouse (loading at supplier, transportation time, unloading at packhouse, loading bay waiting times).
- The total time trucks spend transporting produce from packhouse to market (loading at packhouse, transportation time, unloading at market, loading bay waiting times).
- Total time produce spends at the packhouse(s).
- The total time produce (avocados and apples) are in the system (supplier to packhouse to market).
- The aggregate produce reaching the market.
- The aggregate produce packed.

- The aggregate number of trucks waiting for loading/unloading in each of the supplier, packhouse and market loading bay.
- The cost of transportation and the investment plan.

Kemito Pipfruit will be able to make informed decisions about how to best invest in packing machinery.

The environment maybe used to experiment with the following features:

- The number and type of machines at each packhouse.
- The variability of (un)loading, packing times, transportation times and demand.

1.4 The CM: inputs, outputs, content, assumptions, simplifications;

1.4.1 Inputs and Outputs

1.4.1.1 Experimental Factors (Inputs)

- Packing Machine Investment Plan (The number and size of each machine to install at each packhouse), varied, integer values above 0, comes in three sizes (small, medium or large).

1.4.1.2 Responses (to determine achievements of objectives) (Outputs)

- Percentage of trucks waiting no more than maximum number minutes at the supplier, market and packhouse loading/unloading bays.
- Percentage of produce waiting no more than maximum number minutes at the packing/loading zones.
- Discrepancy in cost between the existing investment plan and the simulation.
- Cumulative percentage of demand met overall and at each market.

1.4.1.3 Responses (to determine reasons for failure to meet objectives) (Outputs)

- Frequency diagrams of waiting time for each truck at the supplier, packhouse and market loading zones accompanied with the mean, standard deviation, minimum and maximum.
- Frequency diagrams of waiting time for each produce in the packing and distribution waiting zones accompanied with the mean, standard deviation, minimum and maximum.
- Time-series of mean queue size per hour for all queues.
- Machine Utilisation for each size of the machine in each packhouse (cumulative percentage).
- Loading Bay utilisation for each loading bay (cumulative percentage).
- Cumulative percentage of discarded produce, packed and unpacked.
- Cumulative percentage of trucks delivering produce after 5pm.
- Cumulative percentage of market and aggregate demand not met.
- Cumulative percentage of trucks which are turned away from loading/unloading produce.

1.4.2 Component Lists

The components for this conceptual model are:

- Produce with type (Avocados/Apples)
- Machines with given distributions of packing times and size.
- Trucks with given variable distribution of transportation times, shipment type and capacity (Supply trucks and market trucks).
- Suppliers with produce supply (thresholds) and fixed loading times.
- Markets with produce demand (thresholds) and loading times.
- Packhouses with given fixed loading times and storage capacity.
- Produce queues with produce type (Avocados /Apples) and storage capacity.
- Loading queues with queuing capacity.

For a detailed component list, see in the appendix.

1.4.3 Process Flow Diagrams

Both apple and avocado trucks/produce will have the same process flow diagrams.

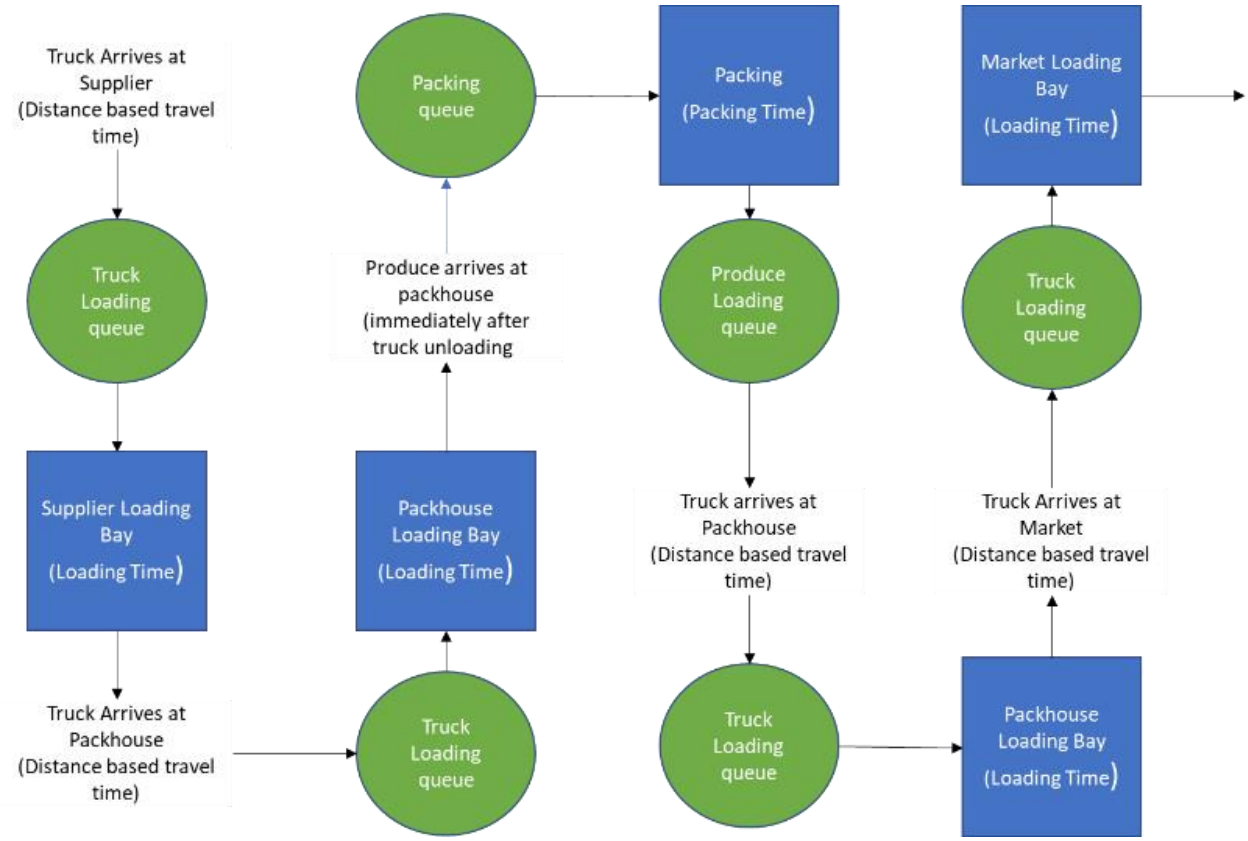

Figure 1: Process Flow Diagram for both Avocados and Apples

1.4.4 Logic Flow Diagrams

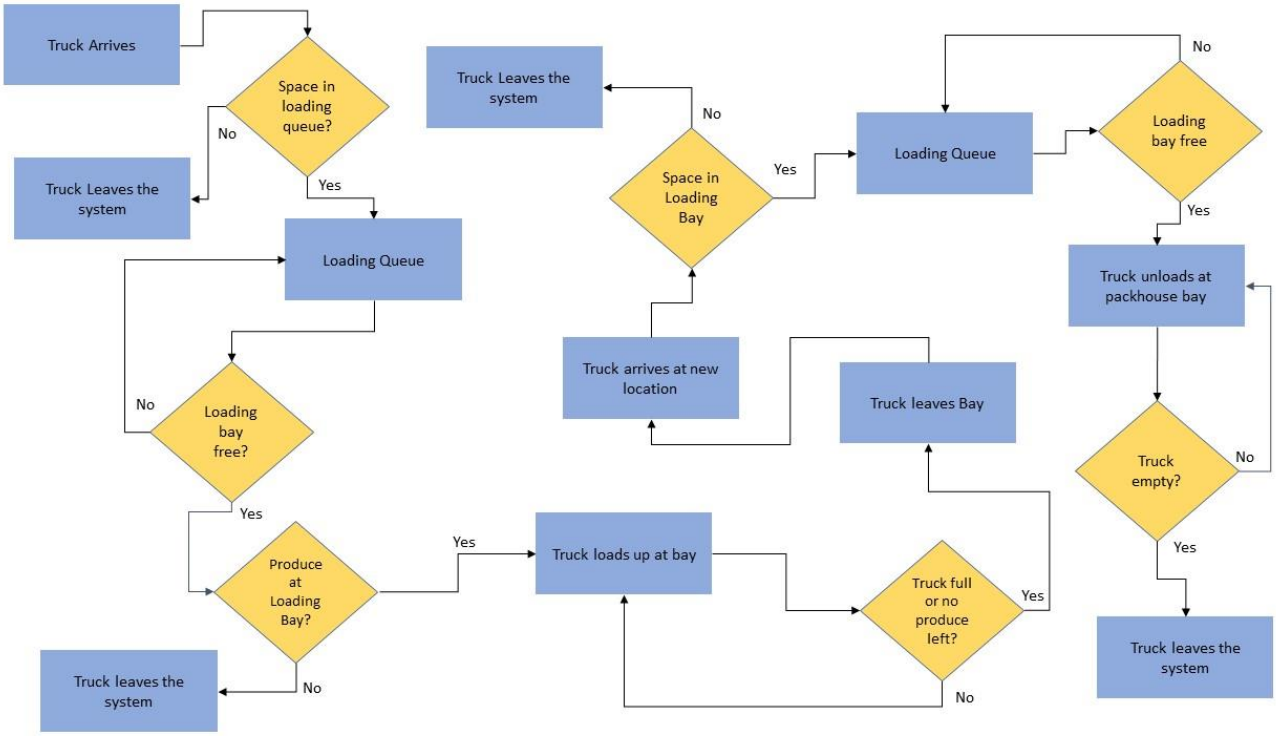

Figure 2: Truck Logic Diagram for both supplier to packhouse and packhouse to market produce delivery

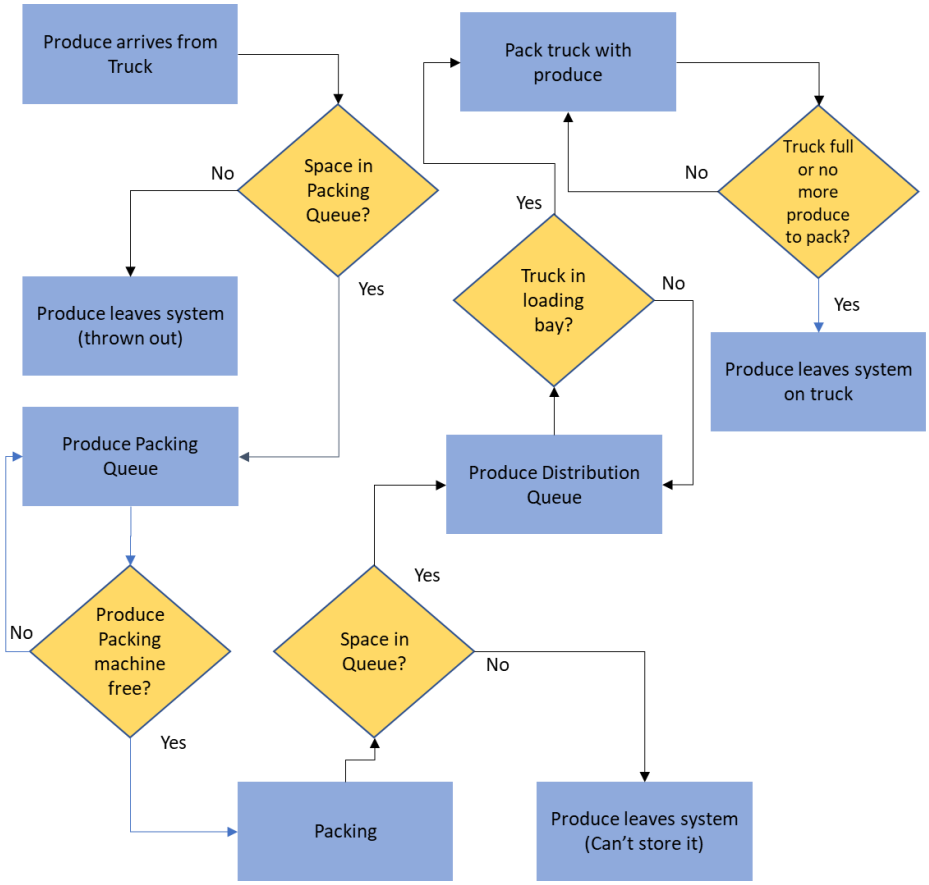

Figure 3: Produce Logic Diagram for either Avocados or Apples

1.4.5 Activity Cycle Diagram

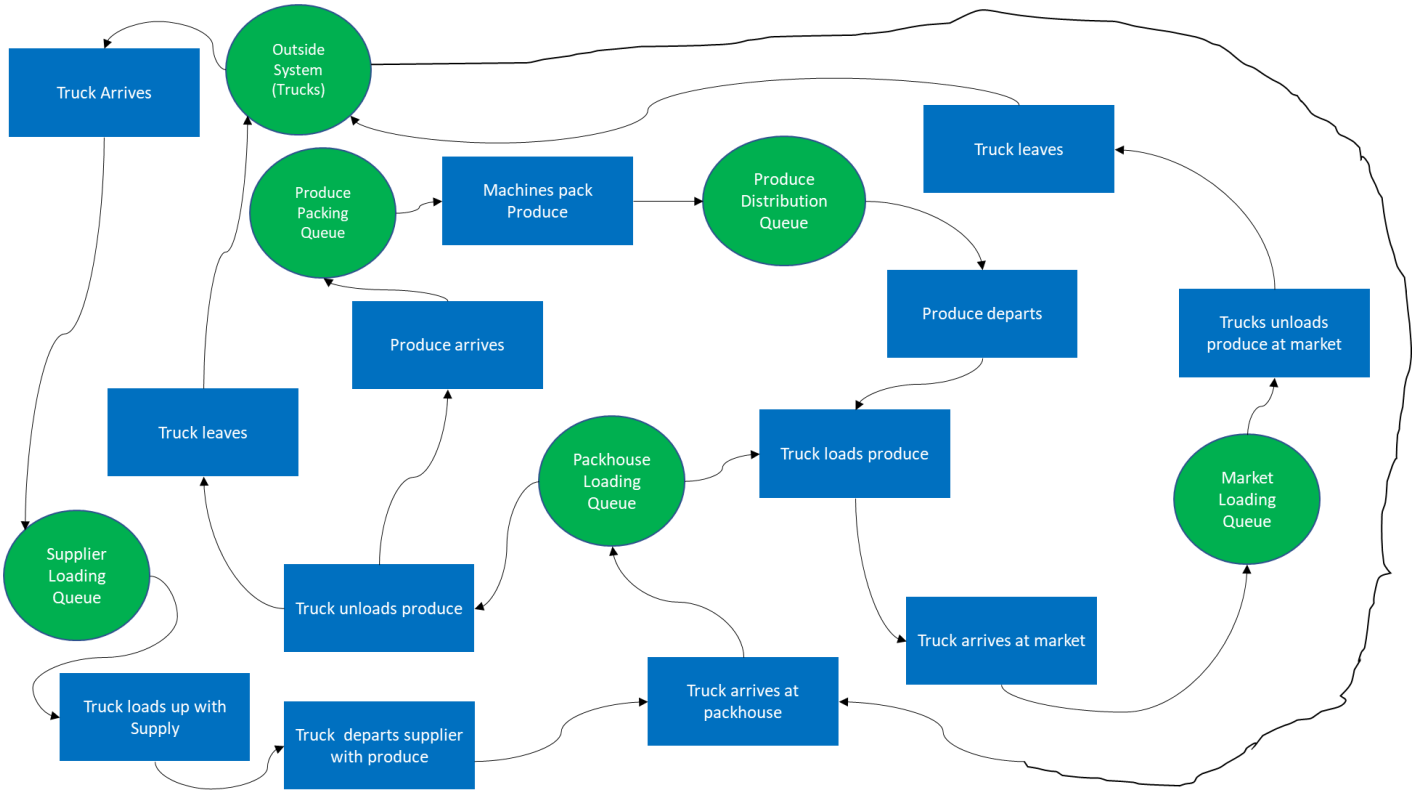

Figure 4: Avocado and Apple Activity Cycle Diagram

1.5 Assumptions

We have made the following assumptions:

- Apples and Avocados are to be shipped in different trucks along different routes and packed by different machines. However, produce is loaded/unloaded in the same bay.
- Administrative, parking, ordering and re-fuelling items are excluded activities to simplify the model, focusing on loading and packing.
- There will always be space in the loading/unloading bay queues for trucks (no bulking, jockeying or reneging).
- We are not concerned with the number of trucks used or where the trucks go after they exit the system. We assume they are under contract.
- Packhouses are open 7am – 5pm seven days a week and no new trucks will be added to the system after 5pm. Operations will continue until the existing entities in the system no longer flow.
- Trucks picking up the produce from suppliers will all arrive at the markets at 7am.
- Both produce types can be stored in the same queues, stored in a storage facility with finite capacity.
- Supply and demand levels are tracked by through additions and subtraction when entities flow to/from nodes.

1.6 Simplifications

We made the following simplifications:

- Model is decomposed into three separate stages; the loading, transportation and unloading of produce between suppliers and packhouses, the packing of produce, and the loading, transportation and unloading of produce between packhouses and markets.
- Trucks flow through the system with produce. The produce is the entity that flows through packing whist trucks flow through transportation.
- We are not concerned with what trucks do outside the system.
- Trucks transport grouped produce entities, assigned by type.
- Transporting produce with trucks required no queues and no rare events are included.
- There are two sets of trucks: Suppliers to Packhouses and Packhouses to Markets. Within each set is a subset: trucks which transport avocados and trucks which transport apples.
- Produce will always enter the packing system. Truck for suppliers will not return to the packhouse with no supply. Trucks will not drive empty to the markets.
- The distributions of the packing and transportation times will be decided upon analysing the data.

1.7 Experiments to run;

The following experiments need to be run:

- Simulate the model (transportation per day) for seven days for each of the ten historically weekly periods for the market.
- Run the simulation with different investment plans. Start with our original investment plan then adjust.
- Switch loading/unloading prioritisation. Prioritise trucks loading produce at the packhouses first. Run a separate set of simulations prioritising unloading next.
- Switch transportation prioritisation. Start with trucks shipping the quantities of produce specified in the optimisation model flows. After, experiment with trucks heading to locations based on lowest/highest number of produce received (Markets) and the amounts already delivered to packhouses (Suppliers).
- Run the prioritisation of loading and unloading produce in different simulations. Prioritise apples first then avocados.
- Switch the produce packing and distributing prioritisation. Prioritise apples first then avocados.
- Switch queue capacities. Start with no capacity. Add changing capacities in subsequent iterations.
- Switch the order markets are prioritised to be delivered to first and which suppliers are prioritised to be have their produce picked up from first.

1.8 Appendices

Component(s)	Include/Exclude	Justification
Entities		
Produce	Include	Flows through the packing process.
Trucks	Include	Flows through the transportation process.
Activities		
Loading/Unloading	Include	Experimental factor, required for loading bay utilisation response.
Packing	Include	Experimental factor, required for machine utilisation response. (Machines are included in the packing process).
Transporting	Include	Required to transport produce between nodes.
Administrating	Exclude	Documentation/delivery forms are prepared prior.
Parking	Exclude	Assume trucks do not need to find parking on arrival (straight to loading bay or waiting zone).
Ordering	Exclude	Assume Kemito's trucks have pre-allocated orders via trucks.
Re-Fuelling	Exclude	Assume: Accounted for in Transportation time.
Queues		
Loading/Unloading queues at Supplier, Market and Packhouses.	Include	Required for loading/unloading waiting time and queue size.
Packing Queues	Include	Required for produce waiting time and queue size.
Transporting, Administration, parking, ordering, re-fuelling queues	Exclude	Not being modelled. Transporting assumed to happen right away.
Resources		
Loading/Unloading Staff	Exclude	Simplification: Represented by loading/unloading
Packing staff	Exclude	Simplification: Represented by packing
Driving staff	Exclude	Simplification: Represented by packing

Component	Detail	Include/Exclude	Justification
Entities			
Produce	Quantity: 1 entity represents 1 unit.	Include	Model number of units to direct to relevant machine.

	Arrival pattern: (Truck Inter arrival time).	Include	Required to model truck arrival
	Attributes: Type – Apple or Avocado.	Include	Investigate the interaction between the models.
Truck	Quantity: 1 entity represents 1 unit. Arrival pattern: Varying with a standard deviation Attributes: Size of shipment and Type – Apple of Avocado	Include	Individual truck flows
		Include	Transportation times vary depending on the route (In brief).
		Include	Required to investigate the interaction between the two transhipment problems.
Activities			
Loading/Unloading	Quantity: 1 entity is 1 bay	Include	Each loading bay has a capacity of one bay.
	Cycle Time: Fixed 30 seconds	Include	Represents throughput, therefore loading bay utilisation, accounts
	Breakdowns/repairs:	Exclude	Assume don't break down.
	Set-up	Exclude	No set up/ transition time.
	Resources:	Exclude	Simplified, no required resources.
	Other:	Exclude	Simplified: No other requirements.
Packing	Quantity: # available units per period per machine type.	Include	Experimental factor, incorporates the number of machines installed at that location.
	Cycle Time: packing rate distribution	Include	Required for machine utilisation,
	Breakdowns/repairs:	Exclude	Assumption: No breakdowns.
	Set-up/changeover:	Exclude	Assumption: No set up required.
	Resources:	Exclude	Assumption: No additional resources
	Other:	Exclude	Assumption: No other
Transporting (Implicit in arrival and departure	Quantity: 1 entity (truck) between two nodes	Include	Transporting of one truck between the nodes.
	Cycle Time: Transportation unique	Include	Need to measure the transportation time of trucks based on the

	to the journey based on nodes.		modes travelled between.
	Breakdown/repairs	Exclude	Trucks don't break down
	Set up	Exclude	Routes already pre planned
	Resources	Exclude	Don't need to stop for extra resources
	Other	Exclude	
Queues			
Loading/Unloading queues at Supplier, Market and Packhouses.	Quantity: 1 for each loading bay	Include	Queuing for the distributions.
	Capacity:	Exclude	No limit to the number of trucks that can wait.
	Queue Discipline: First in first out. Only one queue per location.	Include	No pushing in queues, reneging, balking or jockeying.
	Breakdown/Repair:	Exclude	Assume: No breakdown
	Routing: Loading for supplier and packhouse, unloading for packhouse and market.	Include	Move Entities (Trucks) through the system.
Packing/distributing Queues	Quantity: 1 for both apples and avocados.	Include	apples and avocados to be packed separately but stored in the same place.
	Capacity:	Exclude	Assumption: A lot of storage space (Subject to change on iterations).
	Queue Discipline: First in, first out.	Include	No pushing in queues, reneging, balking or jockeying.
	Breakdown/Repair:	Exclude	Assume doesn't break down.
	Routing: to packing for packing queue, loading for distribution.	Include	Flow entities (Produce) through the system
Resources			
n/a			